RADIOLOGY

NAVSHIPS 93808 (*Non Registered*)

TECHNICAL MANUAL

for

ELECTRONIC MULTIMETER AN/USM-116

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
CLEVELAND, OHIO,

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS

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INSTRUCTIONS

CHANGE 1 TO NAVSHIPS 93808

APPROVED 22 March 1962

TECHNICAL MANUAL

FOR

ELECTRONIC MULTIMETER

AN/USM-116

This permanent change revises the technical manual to reflect changes described in Temporary Correction T-1 and other minor corrections noted since the original printing. This change also covers the addition of official nomenclature for certain components of the AN/USM-116 equipment.

Change 1 is to be inserted in the technical manual immediately. When inserted, Change 1 supersedes Temporary Correction T-1 dated June 1961.

1. Remove superseded pages and insert revised pages as indicated below.

Page	Remove	Insert
Title/ii	Original/Original	Change 1/Change 1
ix/x	Original/Original	Original/Change 1
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INSTRUCTIONS

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1-7/1-8	Original/Original	Change 1/Change 1
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4-7/4-8	Original/Original	Change 1/Original
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4-13/4-14	Original/Original	Change 1/Original
5-27 & 5-28	Original	Change 1
6-5/6-6	Original/Original	Original/Change 1
6-17/6-18	Original/Original	Change 1/Original
6-23/6-24	Original/Original	Change 1/Original

2. Destroy superseded pages after the complete technical manual has been checked against the "List of Effective Pages" page ii Change 1.

3. Make appropriate entry in "Record of Corrections Page" page iv Original.

4. Remove and destroy the superseded Temporary Correction T-1 and insert this "Instructions" sheet just behind the front cover.

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D.C.

IN REPLY REFER TO
Code 24ON-100

From: Chief, Bureau of Ships
To: All Activities concerned with the Installation, Operation, and Maintenance of the Subject Equipment

Subj: Technical Manual for Electronic Multimeter AN/USM-116, NAVSHIPS 93808

1. This is the Technical Manual for the subject equipment and is in effect upon receipt.

2. When superseded by a later edition, this publication shall be destroyed.

3. Extracts from this publication may be made to facilitate the preparation of other Department of Defense publications.

4. Errors found in this publication (other than obvious typographical errors), which have not been corrected by means of Temporary Corrections or Permanent Changes should be reported. Such report should include the complete title of the publication and the publication number (short title); identify the page and line or figure and location of the error; and be forwarded to the Electronics Publications Section of the Bureau of Ships.

5. All Navy requests for NAVSHIPS electronics publications listed in the current issue of NAVSANDA Publication 2002 "Requisitioning Guide and Index of Forms and Publications", Cognizance Symbol I, or in a subsequent issue of the Electronics Information Bulletin should be directed to the appropriate Forms and Publications Supply Point.

R.K.JAMES
Chief of Bureau

RECORD OF CORRECTIONS MADE

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SECTION 1

GENERAL INFORMATION

1-1. INTRODUCTION.

This technical manual describes the circuit theory, installation, operation and maintenance procedures for Electronic Multimeter AN/USM-116. See figure 1-1 for an identifying view of the multimeter and its accessories.

Note

To avoid repetition of lengthy nomenclature, Electronic Multimeter AN/USM-116 will be referred to hereafter as the "multimeter" or "Multimeter AN/USM-116". The terms "prod" and "probe" are used interchangeably in the text.

1-2. FUNCTIONAL DESCRIPTION.

a. PURPOSE. - Multimeter AN/USM-116 is a portable, combination electronic instrument used for general servicing of electronics equipment. It is designed for use where precise voltage, current and resistance measurements are required. It provides a direct reading of values on a single indicating meter mounted on the control panel (see figure 1-1). A high input-impedance permits voltage measurements to be made with only a small percentage of loading on the circuit under test. The multimeter can measure the following: Alternating current (ac) voltages and radio frequency (rf) voltages which are indicated in rms

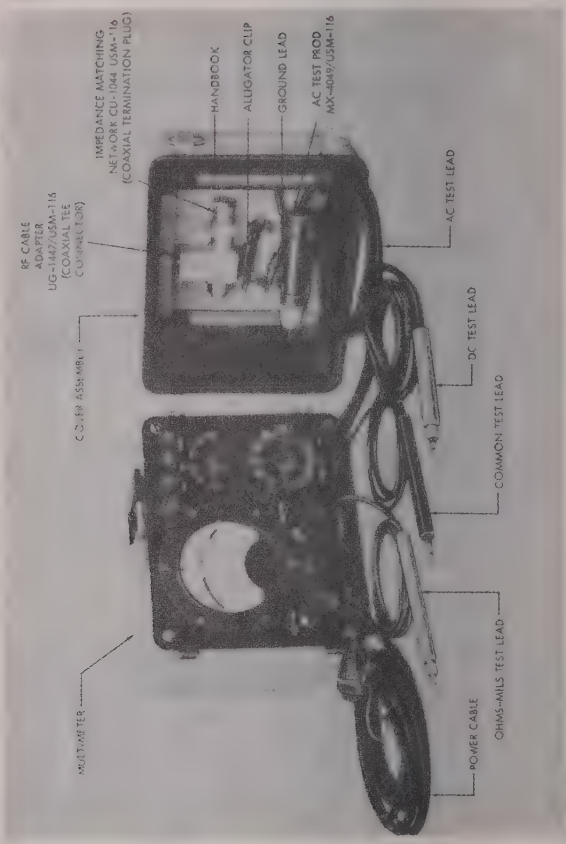

Figure 1-1. Electronic Multimeter AN/USM-116

voltages; (actual deflection is proportional to the rectified peak value) dc volts; dc current and resistance. The specific range for each of these functions is listed as follows:

(1) AC volts: 0.01 to 300 in rms values.
(2) DC volts: 0.02 to 1,000.
(3) DC current: 20 microamperes to 1,000 milliamperes.
(4) Resistance: 0.2 ohm to 1,000 megohms.

b. PHYSICAL CHARACTERISTICS. - An eight-foot ac line cord and four test leads are permanently connected inside the multimeter. These feed out through the bottom of the control panel. Two unshielded test leads, approximately 48 inches long, are used for making OHMS-MILS tests. The shielded lead with the red test probe is used to measure dc volts. A 36 megohm resistor is located in the dc probe to prevent capacitance loading due to the shielding of the lead. A screw-on type alligator clip which is stored in the case cover can be installed on the tip of the probes if the connection is to remain in the circuit under test. The ac test lead is connected to an rf probe. A special ground lead, used when measuring rf voltages, screws into the side of the rf probe. An alligator clip on the ground lead connects to ground of the circuit under test. A special coaxial adapter is used with the rf probe for voltage measurements in 50 ohm coaxial lines. The multimeter is encased in a black impact-resistant phenolic case. A detachable cover is used to store the test leads and accessories. It covers the face of the instrument when it is not in use. A molded neoprene gasket around the open end of the cover forms a water-tight seal when the cover is securely fastened to the case by the four snap-fasteners mounted on the cover. Four rubber feet mounted on bottom of the case support the unit. The multimeter contains a 4-1/2 inch

circular meter having six calibrated scales, each of which is marked with respect to its function and range. A red pilot lamp is energized when the multimeter is turned on.

1-3. FACTORY OR FIELD CHANGES.

No factory or field changes have been made.

1-4. QUICK REFERENCE DATA.

a. TEMPERATURE AND HUMIDITY.

This equipment is designed to operate within the accuracies specified herein over the entire temperature range from minus 28° C to plus 50° C, with a relative humidity up to 95 percent.

b. GENERAL DATA.

(1) Nomenclature: Electronic Multimeter AN/USM-116
(2) Contract Number: NObsr 75953 & NObsr 87359
(3) Contractor: Hickok Electrical Instrument Company, Cleveland 8, Ohio
(4) Cognizant Naval Inspection: Inspector of Naval Material; Cleveland, Ohio
(5) Number of Packages: All equipment including accessories in one shipping container. (Refer to table 1-1.)

c. ELECTRICAL DATA.

(1) Accuracy: (Refer to table 1-0.)

TABLE 1-0. ACCURACY OF EQUIPMENT

FUNCTION	RANGE	ALLOWABLE INACCURACY		
		T & H Range I	T & H Range II	T & H Range III
Temperature		15° C to 35° C	0° C to 50° C	-28° C to 65° C
Relative Humidity		Up to 75%	Up to 90%	Up to 95%
D. C. Voltage	All	+2%	+3.5%	+4%
A. C. Voltage (see NOTE 1, page 1-4B)	Up to 300v	+2%	+3.5%	+4%
	Over 300v	+4%	+5.5%	+6%
D. C. Current	All	+2%	+3.5%	+4%
Resistance (D. C.)	All except 10 megohms or greater	+3%	+4.5%	+5%
	10 megohms or greater	±1° of arc length	±2.5° of arc length	±3° of arc length

Note [1]

For frequencies from 50 cps to 100 mcs. For frequencies from 100 mcs to 400 mcs use the coaxial tee connector and add ±4% additional allowable inaccuracy. Frequency response rated within ±1 db from 20 cps to 700 mcs.

The accuracy of this equipment is defined as a function of the full-scale value for both voltage and current measurements. The following formula shall be used to determine the accuracy of voltage or current measurements:

$$\text{Percentage inaccuracy} = \frac{\text{Indicated value-true value}}{\text{full scale value}} \times 100$$

The accuracy of resistance measurements is defined as the actual percentage deviation between the true value of the resistance being measured and the value indicated by the equipment. The following formula shall be used to determine the accuracy of resistance measurements for values up to 10 megohms:

$$\text{Percentage inaccuracy} = \frac{\text{Indicated value-true value}}{\text{true value}} \times 100$$

The percentage inaccuracy of voltage and current measurements is based upon measuring with the range which gives the greatest angular deflection whereas the percentage inaccuracy of resistance measurements for values up to 10 megohms is based upon measuring with the range which gives the greatest angular deflection between 0 and 10 on the meter scale.

(2) Sensitivity of Indicating Meter: 100 micro-amperes

(3) AC Input Impedance:

15 megohms at 20 cps
5 megohms shunted by 1.2 uuf at 300 kcs
125 kilohms shunted by 1.1 uuf at 50 mcs

(4) DC Input Impedance: 100 megohms

(5) Power Requirements:

115 vac ±10%
50, 60 and 400 cps
Single Phase
40 Watts (Maximum)

TABLE 1-1. PACKAGING DATA

Nomenclature	Volume (cubic feet)	Weight (pounds)
Electronic Multimeter AN/USM-116 (uncrated):	0.435	17
Electronic Multimeter AN/USM-116 (crated)	1.75	30

(6) Frequency Response:

Flat within ± 1 db from 20 cps to 100 mcs (using ac probe alone)

Flat within ± 1 db from 100 mcs to 700 mcs (using ac probe with coaxial tee connector)

(7) Ranges:

AC Volts: 0-1, 3, 10, 30, 100, 300
DC Volts: 0-1, 3, 10, 30, 100, 300, 1000
DC Mils: 0-1, 3, 10, 30, 100, 300, 1000
Resistance: at center scale of 10 ohms: X1, X10, X100, X1K, X10K, X100K, X1M

1-5. EQUIPMENT LISTS.

a. EQUIPMENT SUPPLIED. - Multimeter accessories are listed in table 1-2. Each of these is stored in the case cover when it is not in use.

b. EQUIPMENT AND PUBLICATIONS REQUIRED. - No equipment or publications other than those supplied with the unit are required.

c. SHIPPING DATA. - Cubic inch displacement of the multimeter, crated and uncrated, together with other physical characteristics necessary to determine the proper size shipping box, is listed in table 1-2.

d. EQUIPMENT SIMILARITIES. - Not applicable.

e. ELECTRON TUBE COMPLEMENT. - The multimeter is supplied with a full complement of electron tubes summarized in table 1-3. The location of tubes V2, V3, V4 and V5 and transistor Q1 is shown in the tube socket diagram, figure 5-3. V1 is housed in the AC probe figure 5-8.

TABLE 1-2. ELECTRONIC MULTIMETER AN/USM-116, EQUIPMENT SUPPLIED

Quant. per Equip.	Nomenclature		Overall Dimensions Inches			Volume	Weight
	Name	Design.					
1	Electronic Multimeter	AN/USM-116	6-7/8 H	8-1/4 W	12-3/4 D	0.435 cu ft	17 lbs
1	Adapter, RF Cable UG-1447/USM-116 (Coaxial Tee Connector)	E1	2 H	2-1/2 W	1 D	#	#
1	Ground Lead	W6	4-1/4 L	3/8 Dia.		#	#
1	Clip, Alligator with coupling	E3	2-1/4 L	1/2 Dia.		#	#

All accessories mounted in cover of combination case.

TABLE 1-2. ELECTRONIC MULTIMETER AN/USM-116, EQUIPMENT SUPPLIED (Cont.)

Quant. per Equip.	Nomenclature		Overall Dimensions Inches			Volume	Weight
	Name	Desig.					
1	Network, Impedance Matching CU-1044/USM-116 (Coaxial Termination Plug)	E2	1-1/2 L	7/8 Dia.		#	#
2	Technical Manual NavShips 93808		6-3/4 H	4-3/8 W	3/8 Thk	#	#

All accessories mounted in cover of combination case.

TABLE 1-3. ELECTRONIC MULTIMETER AN/USM-116, ELECTRONIC TUBE COMPLEMENT

Tube	Designation	Quantity
6923/EA52	V1	1
6AU6WA	V2, V3, V5	3
6X4WA	V4	1
2N297A (Transistor)	Q1	1

SECTION 2
INSTALLATION

2-1. UNPACKING AND HANDLING.

There are no special instructions for unpacking the multimeter. It is advisable to save the packaging materials, if practical, until the time when they may be reused for shipment or storage.

2-2. SITE SELECTION.

No special location is required outside of placing the meter on a rigid bench or table where adequate light, ventilation and the necessary power outlets are available.

2-3. POWER REQUIREMENTS AND DISTRIBUTION.

The multimeter will operate to specifications when connected to any 105 to 125 volt, 50 to 400, cycle ac outlet. It requires approximately 40 watts of power.

2-4. INSPECTION AND ADJUSTMENTS. - After unpacking multimeter, no special adjustments are required outside of checking the mechanical zero adjustment (refer to paragraph 3-3c).

a. Inspect the instrument for damage incurred during shipment or storage. Look for broken controls, damaged leads, broken glass in face of meter

and other obvious signs of damage. If equipment is damaged, repair according to instructions in Section 5, or fill out a failure report (refer to paragraph 5-6) and forward it to the Bureau of Ships.

2-5. PREPARATION FOR RESHIPMENT.

The exact procedure for packaging depends on the material available and the conditions under which the equipment will be shipped and/or stored. Use the original packing materials if they are available. Special instructions or precautions relative to protective packing or handling, including shipping forms, etc., should be referred to the officer in charge.

SECTION 3
OPERATOR'S SECTION

3-1. FUNCTIONAL OPERATION.

Multimeter AN/USM-116 can be used to measure dc voltages from 0.02 volts to 1,000 volts. AC voltages can be measured from 0.01 volt to 300 volts. DC current can be measured from 20 microamperes to 1,000 milliamperes. Resistance measurements from 0.2 ohm to 1,000 megohms can be made.

3-2. PREPARATION FOR USE.

a. Carefully place the multimeter upon a sturdy bench or table near a 115 volts ac, 60 cycle power outlet. When positioning the unit consider accessibility, ventilation, lighting and ease of operation and service.

b. Loosen four snap-fasteners and lift off the cover assembly. Layout each lead so that it is free and clear of all other leads. Check to see that each is free of ground connections.

c. Connect the power cable assembly to the power outlet. If outlet is not three terminal grounding type, connect small "pigtail" ground lead on power cable to a suitable ground, in accordance with latest BuShips instruction. Turn the function selector switch from OFF to any desired position. The pilot light should glow. Allow unit to warm-up for

approximately fifteen minutes before taking any measurements. If unit is being used for the first time allow it to warm up for 30 minutes.

CAUTION

The operator should understand the function of each control on the front panel and be thoroughly familiar with the meter scales before making circuit tests. Ignorance of the placement or function of the controls could lead to serious damage to the instrument.

3-3. OPERATING PROCEDURES.

a. DESCRIPTION OF CONTROLS. (See figure 3-1.)

(1) The function selector switch switches in the necessary circuits to make the measurements listed below. It also serves as the ac power switch for the instrument. When it is set in the OFF position both sides of the ac line are disconnected.

FUNCTION	SWITCH POSITION
(a) DC volts positive	"+DC"
(b) DC volts negative	"-DC"
(c) AC volts	"AC"
(d) DC current	"MILS"
(e) Resistance	"OHMS"

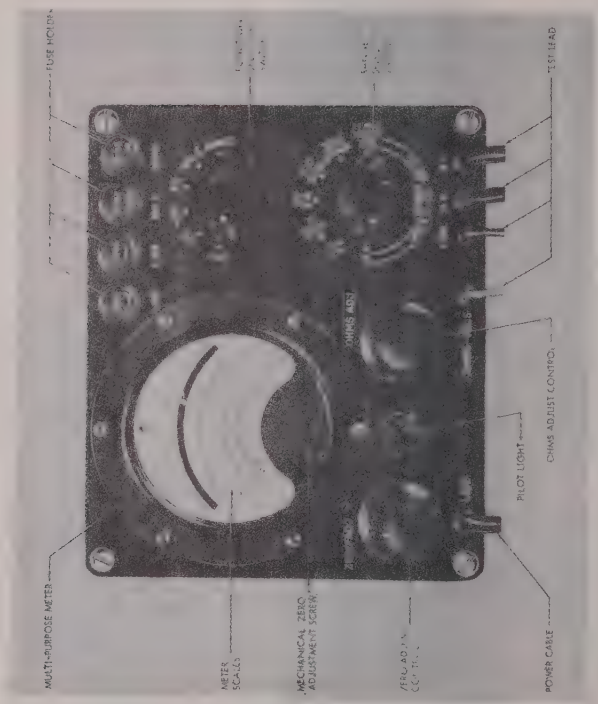

Figure 3-1. Electronic Multimeter AN/USM-116, Front Panel Controls

(2) The range switch is used to select the desired range for a particular measurement. When making ac voltage measurements on the three highest ranges or dc voltage measurements on the four highest ranges the reading must be multiplied by the

following factors: 10 on the 0 to 30 volt range; 100 on the 0 to 100 and 0 to 300 volt ranges; 1000 on the 0-1000 volt range (for dc voltages only). When making resistance measurements, the reading on the ohms scale is multiplied by the factor following the multiplication sign "X"; these vary from 1 to 1, 000, 000 depending upon the position of the selector switch.

(3) The OHMS ADJ. control permits adjustment of the ohmmeter ranges for proper calibration.

(4) ZERO ADJ. This is a dual control. Adjustment of the back knob serves to balance multimeter for proper accuracy when measuring dc volts, ac volts and ohms.

(5) The red knob of the ZERO ADJ. control permits a secondary adjustment of the low ac voltage ranges.

(6) The face of indicating meter M1 contains six scales. The three lower scales are used with the 1, 3 and 10 ac volt ranges. The blue OHMS scale is used for all resistance measurements. All other measurements of ac volts, dc volts and dc milliamperes are made on the two top scales.

b. SEQUENCE OF OPERATION.

The sequence of operation for the AN/USM-116 is similar to all electronic multimeters. Instructions on how to perform particular measurements for each function are given in paragraph 3-4.

c. METER ADJUSTMENTS.

With the power off, check to see if meter pointer rests at zero. If pointer does not rest at zero, carefully turn meter mechanical zero adjustment screw (located just below the meter scales, see figure 3-1) with a screwdriver until pointer coincides

exactly with the zero mark on the scale. If, during the course of normal operation when the meter is turned on, a mechanical zero-adjust check is desired, disconnect all test leads so that there is no input to the meter. Then, turn the function switch to the MILS position before turning the mechanical zero adjustment screw.

3-4. TEST PROCEDURES.

a. DC VOLTAGE MEASUREMENTS.

(1) With function switch in +DC position, set range switch to the approximate range of measurement.

CAUTION

If voltage is unknown, always set range switch to highest voltage range.

(2) Check meter to see if pointer rests at zero If it does not, rotate black ZERO ADJ. control until meter registers zero. Move function switch from +DC to -DC. If meter pointer shifts as function switch is moved, it indicates that the mechanical zero adjustment is incorrect. If necessary, readjust mechanical zero as described in paragraph 3-3c.

(3) Place COM lead to negative or ground side of circuit to be tested. Place DC probe on the positive terminal. If the polarity of the probes is correct, the pointer will move up-scale (to the right). If the polarity is reversed, the pointer will move down-scale (to the left). Correct for reversed polarity by changing position of the FUNCTION switch rather than reversing the leads. For dc measurements in the ranges of zero to 1V, 10V, 100V or 1000V, read the upper scale (scale above the mirror). For dc voltages in the ranges of zero to 3V, 30V or 300V, read the scale immediately below mirror.

Note

The purpose of the mirror is to eliminate errors due to parallax. When reading the meter view the scale so that the pointer coincides with the image in the mirror.

b. DC MILLIAMPERE MEASUREMENTS.

(1) To make a current reading, place the function switch to the MILS position and the range switch to the desired range. Connect the red OHMS-MILS test lead and the COM lead in series with the circuit under test. The two scales used for dc voltage measurements are also used for dc current measurements. Since the milliammeter function does not make use of the bridge circuit, the multimeter may be used as a multi-range milliammeter without being connected to an external power supply.

CAUTION

Be sure that the range switch is positioned properly before connecting the meter into the circuit under test. Do not apply excessive current for long periods. The multimeter is carefully safe-guarded against overloads, but overloads sharply reduce input impedance so that components in the circuit under test can be seriously damaged.

c. OHMMETER MEASUREMENTS.

(1) Place function switch to the OHMS position. Set the range switch to the desired range. Hold the probes of the OHMS-MILS test lead and the COM lead together and turn black knob on ZERO ADJ. control until the meter pointer registers zero. With the two

probes now separated, set the OHMS ADJ. control so that the meter reads infinity (∞) at the end of the blue ohms scale.

Note

When making resistance measurements, keep hands clear of probe tips; not to avoid shock which is not a danger during resistance measurements but to prevent body resistance from producing false readings.

(2) Connect the test probes across the terminals of the unknown resistance. Note the position of the meter pointer on the OHMS scale. Multiply this reading by the factor indicated by the range switch.

Example: An unknown resistance value is placed in series with the ohms test lead and the common test lead. The range switch is set to the range at which the indicated resistance can be easily read on the OHMS scale of the meter. The indicated reading is 56 and the range selector is set at the X100 position. The resistance value is 56 X 100, or 5600 ohms. If the range switch had been in the X1 position, the resistance value would be 56 X 1, or 56 ohms.

CAUTION

De-energize circuit under test before measuring resistance. Disconnect at least one side of components being checked for resistance value. Reconnect lead immediately after making test.

d. AC OR RF VOLTAGE MEASUREMENTS.

(1) GENERAL. The AC probe and the COM test probe are used for ac measurements in the low frequency ranges. At higher frequencies (above 50 kc) the short ground lead on the AC probe is substituted for the COM probe. If a high degree of accuracy is required when making ac voltage measurements above 100 mc, the AC probe in inserted into a coaxial tee connector as shown in figure 3-2. Accurate ac voltage measurements can then be taken at frequencies up to 700 mc. It should be remembered, however, that the maximum voltage that can be measured at radio frequencies decreases linearly from 300 volts at 50 mc to only 20 volts at 700 mc.

(2) If voltages are to be measured above 100 mc in 50 ohm coaxial lines, insert the AC probe into the coaxial tee connector as described in steps (a) and (b). When making measurements in un-terminated lines, install the coaxial terminator plug E2. The maximum power dissipation of the load resistor in E2 is one watt.

(a) Unscrew the white tip on the AC probe by turning the tip in a counterclockwise direction.

(b) Insert AC probe into the coaxial tee connector. Screw in carefully until the probe body bottoms against the top of the connector tee assembly.

(3) To make ac voltage measurements, proceed as follows:

(a) Set function switch to the AC position. Set the range switch to the 300 volt range. Adjust the meter pointer for a zero reading by using the black

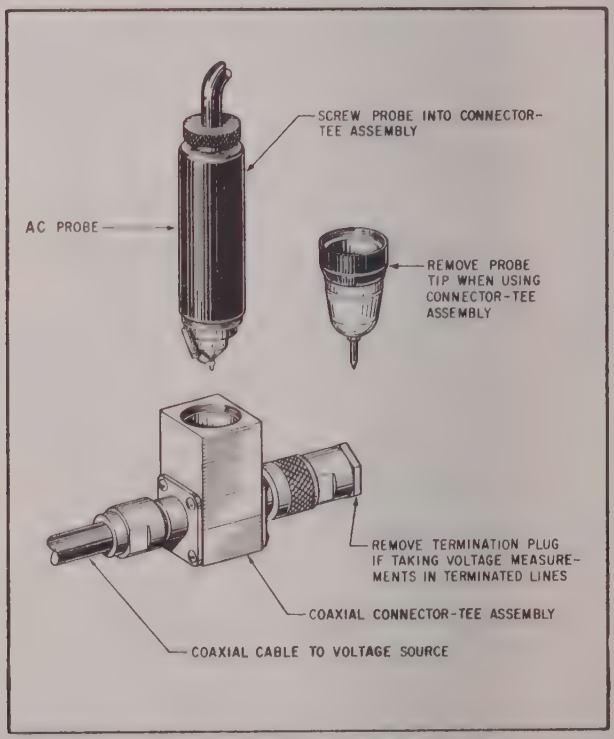
SCREW PROBE INTO CONNECTOR-TEE ASSEMBLY
AC PROBE
REMOVE PROBE TIP WHEN USING CONNECTOR-TEE ASSEMBLY
REMOVE TERMINATION PLUG IF TAKING VOLTAGE MEASUREMENTS IN TERMINATED LINES
COAXIAL CONNECTOR-TEE ASSEMBLY
COAXIAL CABLE TO VOLTAGE SOURCE

Figure 3-2. Installation of AC Probe in Connector Tee Assembly

ZERO ADJ. control. Move the range switch to the one volt range and adjust the meter pointer for a zero reading by using the red ZERO ADJ. control.

Note

The ZERO ADJ. controls should not have to be readjusted as the range switch is moved to different positions.

(b) Turn range switch to the desired range. For greater accuracy, select a range which will give approximately a center scale reading. For frequencies below 50 kc, place the COM probe on the lead ground terminal of the circuit under test. If a number of voltages in this frequency range are to be made with respect to ground on the same piece of equipment, the probe on the COM lead can be permanently connected to the ground terminal by using clip E3.

CAUTION

Never connect the common test lead to the high potential portion of any circuit.

(c) For voltage measurements at frequencies above 50 kc, attach ground lead W6 to the side of the AC probe. Connect alligator clip on ground lead W6 to the ground terminal. Touch test prod on AC probe to test point and read proper scale on meter for value of ac voltage.

WARNING

To avoid the possibility of dangerous electrical shock, hold probe with hand well away from the tip.

(d) The 30, 100 and 300-volt ranges are read on the two upper VOLTS scales. The three lowest ac voltage ranges, 10, 3 and 1-volt, are read on the

three bottom scales, respectively.

e. SECURING EQUIPMENT.

To secure equipment, turn function selector switch to the OFF position. Normally it will not be necessary to reinstall the cover assembly each time the multimeter is used. However, if this is necessary, coil the test leads and carefully place them inside of the cover. Then, position the cover over the face of the control panel and secure it in place with the four snap fasteners.

3-5. OPERATOR'S MAINTENANCE.

a. OPERATING CHECKS AND ADJUSTMENTS. - It is essential that the operator keep watch over his equipment in order to detect minor faults before they develop. It is suggested that a routine operational check be made at the beginning of each period of operation. This check may consist of the following procedures:

(1) Check exterior of multimeter to see if there is any obvious damage to the multimeter and to its accessories. It should be clean and have a well-kept appearance. Check each control and switch to see if it functions properly. Turn on multimeter and check to see if the pilot light is energized.

(2) Check mechanical zero-adjustment as described in paragraph 3-3c. Move the range switch through all of its positions while observing the action of the meter pointer. If the zero adjustment changes position as the range switch is moved from the 1000 volt position to the one volt position (with no input on the +DC function) it indicates that tube V2 or V3 in the bridge circuit may be faulty.

b. REPLACEMENT OF PARTS. The correction of minor faults by simple replacement procedures is described as follows:

(1) PILOT LAMP. Replace the pilot lamp by unscrewing the pilot light holder cap located just below the meter face. Grip the base of the lamp between the fingers and pull it from threaded cap portion of pilot light holder. Insert new lamp and replace cap in holder.

CAUTION

Use authorized replacement parts only.

(2) FUSES. To replace fuses, press in on fuse holder and turn it in a counterclockwise direction. Pull fuse from holder, insert new fuse and reinstall fuse holder in socket. Be sure replacement fuse is correct type and rating.

CAUTION

Never replace a fuse with one of higher rating. Note that the MILS and OHMS fuses are low dc resistance instrument-type fuses. If a fuse burns out immediately after replacement, do not make a second replacement until the cause of the failure has been corrected.

(3) To replace tubes, remove the multimeter from the case assembly and proceed as described in Section 5.

SECTION 4

PRINCIPLES OF OPERATIONS

4-1. OVERALL FUNCTIONAL DESCRIPTION.

a. GENERAL. - To understand the principles upon which the operation of Multimeter AN/USM-116 is based, refer to figures 4-1 through 4-8 and to figure 5-3 during the following explanation.

b. SIMPLIFIED CIRCUIT DESCRIPTION.

(1) The multimeter can measure ac and dc voltages as well as resistance and current. When measuring ac voltages, the signal is first rectified by the diode in the probe. The signal must be rectified because the meter circuit is sensitive only to dc voltages. When dc voltages are measured, the AC probe containing the diode rectifier is not needed.

(2) The dc or ac voltage to be measured is applied across a voltage-divider network so that the total input impedance of the multimeter remains constant when the position of range switch S2 is changed for various levels of input voltage.

(3) The meter is connected across a balanced bridge network. With no input, the bridge circuit is balanced and the meter reads zero. When the bridge is unbalanced by an input voltage, the meter pointer is deflected up-scale. The extent of deflection is in proportion to the strength of the input voltage. The

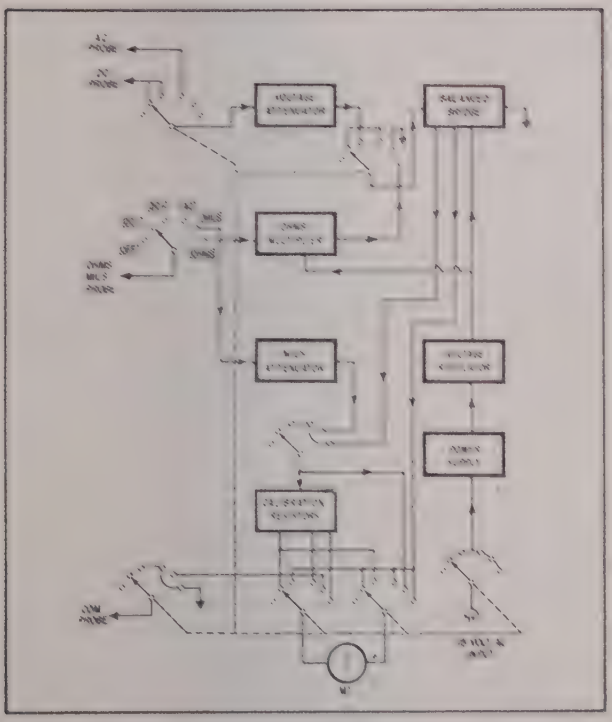

Figure 4-1. Electronic Multimeter AN USM-116, Overall Functional Block Diagram

meter actually measures peak ac voltage (on the ac function) but it is calibrated in rms values.

(4) Switch S1 is used to select the desired function. When measuring dc voltages, it may also be used to change the polarity of the multimeter from

-DC to -DC, thereby eliminating the necessity of reversing the test leads. Switch S2 is used to connect the necessary resistance into the circuit for each range. The resistance across the voltage dividers networks reduces the input signal to a level suitable for application to the bridge. There are three voltage-divider networks, one for each function.

(5) The ohmmeter section also utilizes the bridge circuit. When an unknown resistance is placed between the OHMS-MILS lead and the COM lead, the bias voltage on V2 decreases in proportion to the unknown resistance. The value of the unknown resistance determines the degree to which the bridge is unbalanced and hence the magnitude of the meter pointer deflection. No battery supply is required for the ohmmeter circuitry.

(6) The milliammeter function does not make use of the bridge circuit. The range switch S2 connects various shunts across the meter to increase the range of current measurement.

(7) A voltage regulator V5 tends to maintain the B- supply voltage to tubes V2 and V3 at a constant value despite changes in line voltage. Each of these circuits is described in greater detail in the following paragraphs.

4-2. FUNCTIONAL SECTIONS.

a. BRIDGE CIRCUIT (see figure 4-2). - The input selected by the function switch is supplied to a balanced bridge circuit that is common to all voltage and resistance measurements. The bridge circuit consists of two 6AU6WA pentodes in a balanced dc circuit. The meter is connected between the cathodes of the two pentodes and indicates the degree to which

the circuit is balanced or unbalanced. The bridge is properly balanced when the meter indicates zero with no voltage applied to the grid of V2.

(1) The input voltage is fed through a voltage divider to the grid of V2. When no input voltage is fed to the grid, the current through tubes V2 and V3 is equal and the meter reads zero. When a voltage is applied, V2 conducts more than V3, thus causing an unbalanced condition across the meter. The unbalanced condition causes a deflection of the meter pointer which is proportional to the magnitude of the input voltage.

(2) Balance of the bridge is accomplished by varying the screen potential on V2 and V3 with zero adjust control R35 until the currents through the cathodes are equal (with no voltage applied to the grid of V2).

(3) Operating bias of the bridge is adjusted by the internal 50 kilohm bias control R57. Proper bias is obtained when the grid currents in the 6AU6WA tubes are at a minimum, as indicated by the absence of shift of the meter pointer from the zero position when the range switch is switched through its dc voltage positions. Momentary surges should be disregarded. Power required for operation of the bridge circuit is maintained at a near constant value by the voltage regulator circuit.

(4) A high degree of degeneration is characteristic of the bridge circuit thus reducing the unbalancing effect caused by tube replacement.

(5) The bridge circuit is not utilized for dc current measurements.

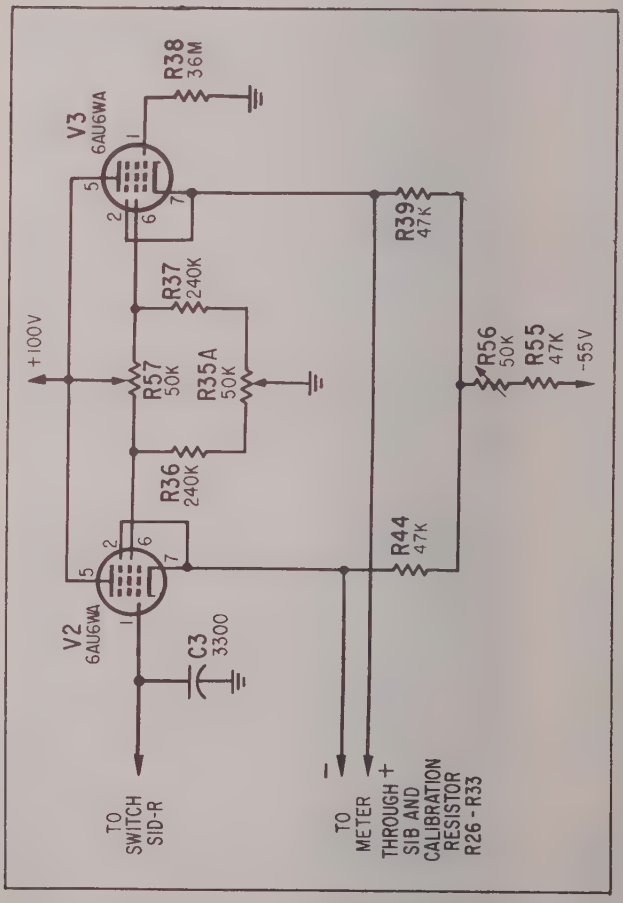

Figure 4-2. Bridge Circuit, Schematic Diagram

b. DC VOLTMETER CIRCUIT (see figure 4-3). - The input voltage is fed through 36 megohm isolation resistor R3 (in DC probe) to function switch S1. From the function switch the voltage is fed to the range switch and then to the grid of V2 in the bridge circuit. This unbalances the bridge as described in paragraph 4-2a and causes the meter pointer to deflect in proportion to the magnitude of the input voltage. Isolating resistor R3, contained in the dc probe, serves to isolate the shunt capacitance of the shielded test lead from the circuit under test. R3 in series with resistors R4 through R10, forms a voltage attenuator. The attenuation is such that the voltage applied to the bridge circuit is the same for full scale deflection on each range. Calibration of the entire dc measuring circuit is accomplished by the internal calibration potentiometer R26. Either plus or minus dc voltages may be measured by setting the function switch to the desired polarity. The high impedance of the voltage attenuator minimizes the loading effect on the circuit under test.

c. AC VOLTMETER CIRCUIT (see figure 4-4). - Diode V1, located in the AC probe, together with charging capacitor C2, acts as a peak detector. The dc output of the detector is filtered by capacitor C1 before being applied to the voltage attenuator network. The attenuated voltage is applied to the bridge and measured in the same manner as dc voltages.

(1) The slight negative contact potential developed by diode V1 is cancelled by application of a small positive voltage supplied by a divider network consisting of R47 and R35B. The positive potential is adjusted to a suitable value by means of the ZERO ADJ. control on the front panel.

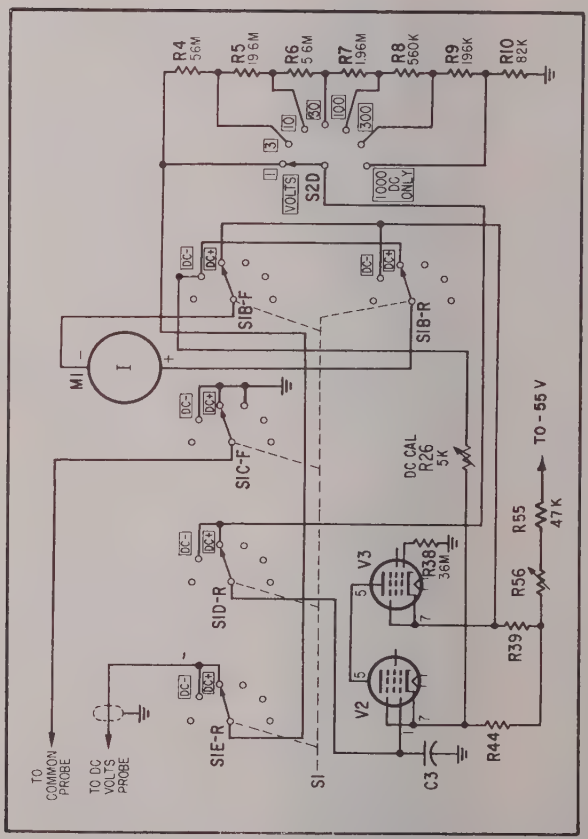

Figure 4-3. DC Voltmeter Circuit, Schematic Diagram

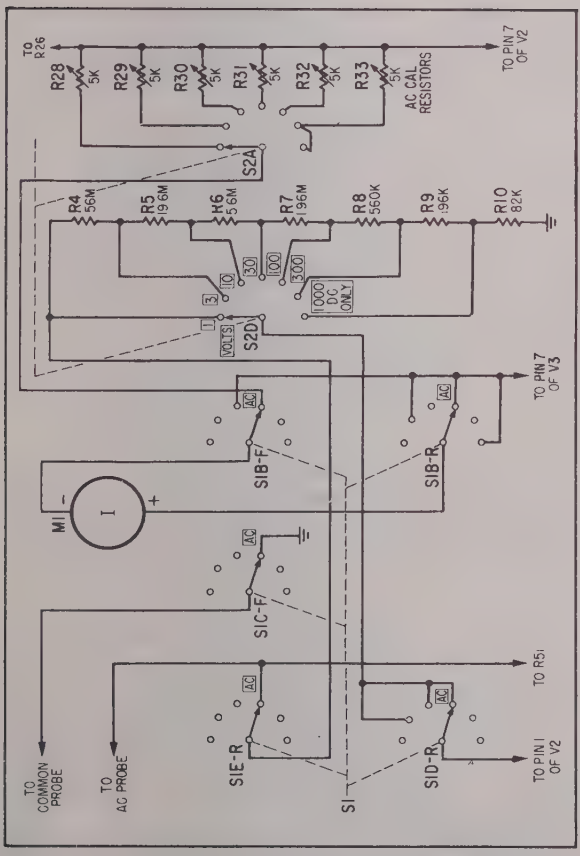

Figure 4-4. AC Voltmeter Circuit, Schematic Diagram

d. OHMMETER CIRCUIT (see figure 4-5). The ohmmeter circuit consists of a group of precision resistors in the ohmmeter multiplier connected in series with the internal dc voltage supply.

(1) The ohmmeter receives its voltage from the regulated heater supply, thus eliminating the problem of periodic battery replacement.

(2) The ohmmeter supply is at a 10 ohm impedance. When a resistance of 10 ohms is being measured, one half of the voltage is across the resistance and one half is across the power supply, thus giving a half scale indication or 10 ohms.

(3) When the ohmmeter test leads are shorted together the voltage applied to the bridge input circuit is zero. When the test leads are disconnected from each other, the full voltage of the ohmmeter power supply is applied to the bridge circuit. Under this condition the sensitivity of the bridge circuit is varied by the OHMS ADJ. control until the dc voltage which is applied to the bridge is sufficient to cause the meter to indicate full scale or "infinity" ohms.

(4) When an unknown resistance is connected between the OHMS MILS probe and the COM probe, it is placed in series with one or more of the precision resistors in the ohmmeter multiplier. The resulting voltage drop across the unknown resistance is proportional to the value of the unknown resistance. This voltage drop is applied to the grid of the bridge circuit. The resultant meter deflection is indicated in terms of ohms.

(5) Lamp VR1 is connected across the input leads so that if a voltage is accidently fed to the ohmmeter input the lamp will conduct causing fuse F1 to blow and prevent dam

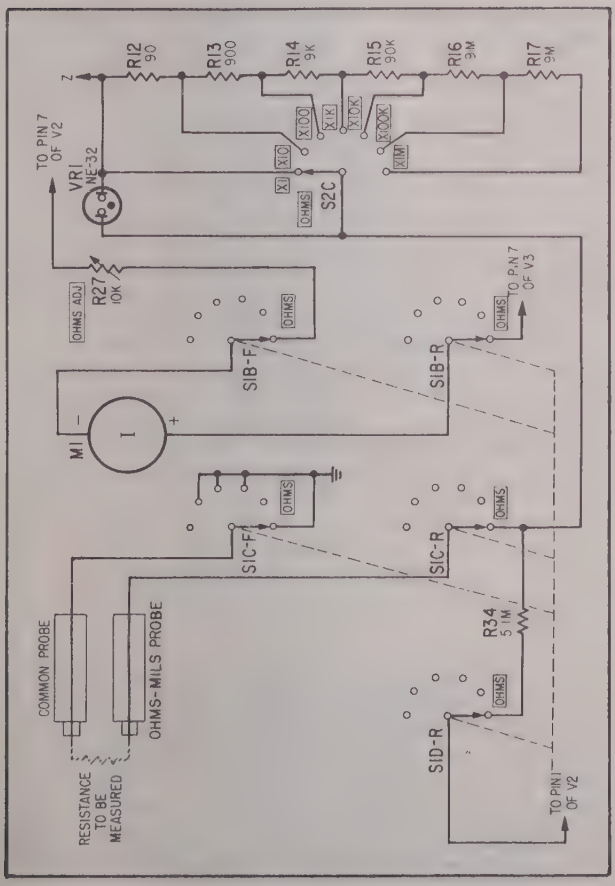

Figure 4-5. Ohmmeter Circuit, Schematic Diagram

age to the precision resistors in the voltage divider circuit.

e. DC MILLIAMPERE CIRCUIT (see figure 4-6). DC current up to 1,000 milliamperes can be measured. For measurement of current flow the COM and OHMS-MILS probes are connected in series with the circuit under test. The current flows to switch S1, then through fuse F2 to meter M1. The meter is connected in parallel with the resistors in the mils attenuator. Two high-resistance diodes (CR1 and CR2) and connected in parallel across the low resistance precision resistors; one in the forward direction, the other in the reverse direction. When a current in excess of 1,000 ma is applied, the diodes pass this current allowing time for fuse F2 to open circuit. This prevents any damage to the meter and to the shunt precision resistors. Under normal operating conditions the diodes act as open circuits and do not conduct.

CAUTION

Do not apply excessive current for long periods.

f. POWER SUPPLY CIRCUIT (see figure 4-7). - The power supply is a convential full-wave circuit. It supplies positive plate and screen potentials for tubes V2, V3 and V5. Fuses F3 and F4 are incorporated as protective measures against overloads. Capacitor C5A is a filter for the power supply. Pilot lamp DS1 is connected across the 6.3 filament winding of V4. Another winding on the secondary supplies the regulated heater voltage. This voltage is rectified by diodes CR3 and CR4, (full-wave rectification) and applied to transistor Q1. Transistor Q1 is connected as an emmiter-follower and acts as a voltage

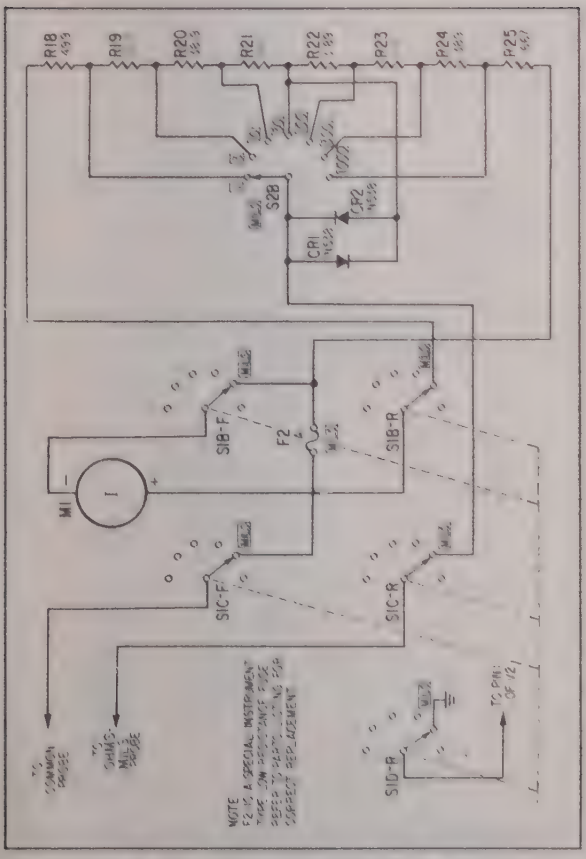

Figure 4-6. DC Milliampere Circuit, Schematic Diagram

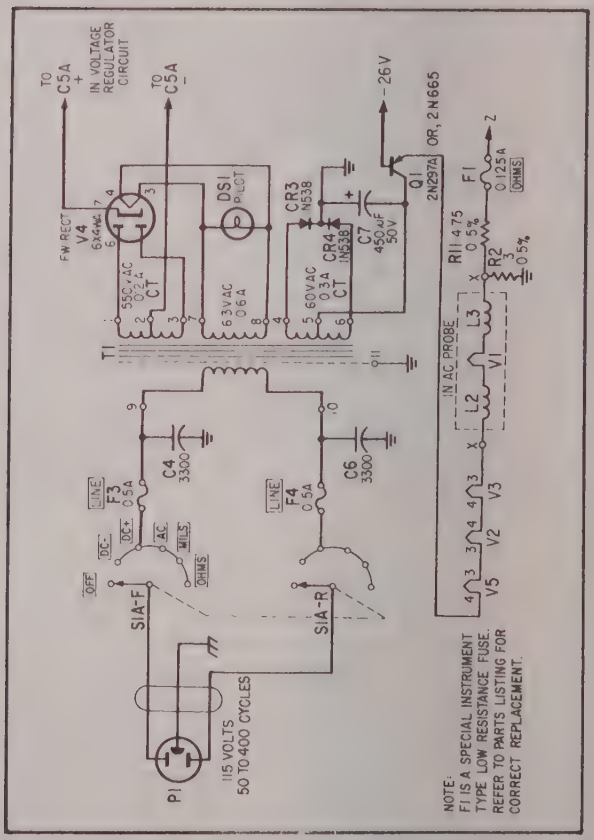

Figure 4-7. Power Supply Circuits, Schematic Diagram

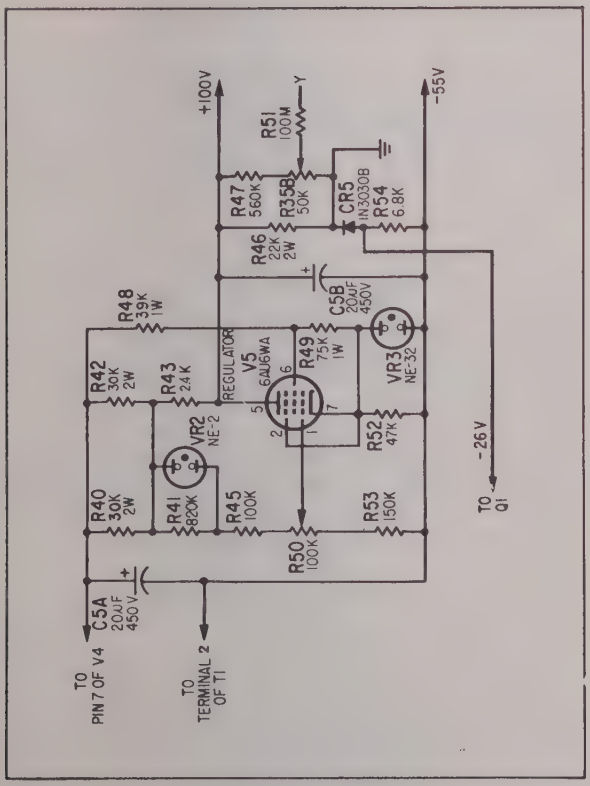

Figure 4-8. Voltage Regulator Circuit, Schematic Diagram

regulator for the heater supply voltage.

g. VOLTAGE REGULATOR CIRCUIT (see figure 4-8). - Design of the voltage regulator is such that it insures stable regulated B+ voltage for tubes V2 and V3 despite variations in load demands or in supply voltage fluctuations. Regulation of the entire B supply is accomplished by a shunt-type pentode regulator tube V5.

(1) The negative B supply lead is clamped at a definite level with respect to the chassis ground by gaseous regulator tube VR3. The regulated positive B supply is referenced to B minus through the voltage divider R41, R45, R50, R53 and the gaseous regulator tube VR2. Any tendency of the total regulated B supply voltage to change due to changes in either the load current or supply voltage will cause a change in the voltage drop across the voltage divider. These changes are applied to the control grid of tube V5 in such a relationship as to cause the regulator to correct for the change in voltage.

SECTION 5

TROUBLE-SHOOTING, SERVICE AND REPAIR

5-1. GENERAL.

a. Multimeter AN/USM-116 is designed so that preliminary trouble-shooting checks can be performed without removing the multimeter from the case. If these checks are performed and the trouble still exists, then it is necessary to remove the instrument from the case.

b. In tracing faults, an orderly and systematic procedure should be followed. Troubles are first localized within a particular system (refer to table 5-1). They are then isolated within a particular section in the system (refer to table 5-2) and finally, the faulty component within the section is located. For information on additional trouble-shooting procedures, attention is called to the *Handbook of Test Methods and Practices*, NavShips publication 91828. Refer also to the *Electronics Maintenance Book*, NavShips 900,000; and to the *Electronics Information Bulletin*, NavShips 900,002. In addition, it is advisable to check the Electronics Equipment History Card, NavShips 536; the Repair Record Card, NavShips 529; the Alteration Record, NavShips 530; and the Resistance Test Record Card, NavShips 531.

5-2. TEST EQUIPMENT AND SPECIAL TOOLS.

a. In order to perform the trouble-shooting pro-

cedures described in this section, precision test equipment, such as the Electronic Multimeter AN USM-116, or equivalent, should be available. In the absence of a multimeter, individual meters of suitable range may be used. DC voltmeter sensitivity of not less than 20,000 ohms per volt is required for accurate test measurement.

b. No special tools are required for maintenance and trouble-shooting procedures.

5-3. OVERALL TROUBLE-SHOOTING.

a. PRELIMINARY CHECK. - The first step in trouble-shooting the multimeter is to make a visual inspection. This should be a detailed visual inspection of all components and controls. Look for loose connections, burned parts and other possible sources of trouble. Burned parts may make their presence known by their distinctive odor. Obvious troubles, such as open filaments and fuses, shorted resistors, leaky capacitors and loose connections can usually be found by the technician.

(1) If the pilot light does not glow when the function switch is moved from the OFF position, check the pilot lamp (refer to paragraph 3-5b(1)) power receptacle, line cord and line fuses.

(2) If the meter does not operate properly on a specific function, check to see if the test lead feeding the input signal to the faulty section of the multimeter is open. If the fault lies in the dc function,

check to see if R3, which is in the dc probe handle, is open. If the fault lies in the ac function, check to see if any of the components in the AC probe are open or broken. Check zero adjustment on the ac ranges. If there is any meter pointer deflection at all, it indicates that B- voltage is available to tubes V2 and V3 in the bridge circuit.

(3) If the ohmmeter or milliammeter functions do not operate properly, check fuses F2 and F1 (refer to paragraph 3-5b.2) for fuse replacement procedures).

(4) Tubes that are thought to be faulty should be tested. Tube substitution - replacing suspected faulty tubes with known good ones - is a method of remedying many troubles. Tapping suspected tubes with the finger or jarring the unit may disclose intermittent trouble.

b. ELECTRICAL INSPECTION. - If the visual inspection fails to locate the fault, an electrical inspection must be made. The electrode voltage of all tubes should be checked at the tube sockets, and the measured values compared with those given in figure 5-3. The operating voltages of all control circuits should also be determined, and then compared with those shown in figure 5-9 (see test points ⏢⏢⏢ and ⏢⏢). Voltages differing greatly from specified values indicate a fault in the circuit under test. When incorrect voltages are found, resistance checks should be made in order to determine the cause. The resistance values are also given on figure 5-3.

c. SYSTEM TROUBLE-SHOOTING CHART. - After completing the preliminary and electrical inspection checks, follow the service steps described

in table 5-1. Refer to the block diagram, the schematic diagrams, the tube location diagram and the trouble-shooting tables when trying to pin-point troubles within a particular system or circuit.

Note

To find the physical location of a part identified by its reference designation symbol, turn to the parts location views, figures 5-4 through 5-8. Also refer to SECTION 6, PARTS LIST.

5-4. FUNCTIONAL TROUBLE-SHOOTING.

a. PREPARATION. - To trouble-shoot functional sections of Multimeter AN/USM-116, the instrument must be removed from its case. This is accomplished as follows:

(1) Remove two screws (see figure 5-1) which secure the small panel to the back of the case assembly.

(2) Take out three screws securing the chassis to the back of the case assembly.

(3) Remove four screws, one of which is located at each corner of the control panel.

(4) Carefully pull case assembly away from the front panel and chassis assembly.

b. To gain access to components on the power supply chassis and the function selector and range switch panels, proceed as follows:

(1) Remove two screws (A, figure 5-2) from underside of the chassis assembly. Swing the hinged

TABLE 5-1. MULTIMETER SYSTEM TROUBLE-SHOOTING

Step	Preliminary Action	Normal Indication	Next Step
1	Set function switch to +DC. Rotate ZERO ADJ. control. Rotate range switch thru its seven positions.	Pointer of meter should deflect with rotation of ZERO ADJ. control. Pointer should zero on each setting of range switch.	If no indication or failure to zero, adjust pointer, check bridge circuit (refer to table 5-2).
2	Set function switch to +DC. Set range switch at proper range of voltage to be measured. Apply a known source of +DC voltage.	Meter should read accurate dc voltage.	If no indication, check voltage dividing network. Check power supply. Check bridge. If reading fluctuates, check bridge and regulator (refer to table 5-2).
3	Set function switch to AC position. Set range switch to correct range.	Meter should read correct ac voltage.	If no indication, check ac probe, bridge network, voltage divider and

TABLE 5-1. MULTIMETER SYSTEM TROUBLE-SHOOTING (Cont.)

Step	Preliminary Action	Normal Indication	Next Step
3 (cont)	Apply a known source of ac voltage.		power supply (refer to table 5-2).
4	Set function switch to OHMS position. Connect OHMS-MILS test probe and COM lead across a precision resistor of low resistance rating, then across one of high resistance. Set range switch in accordance with resistance to be measured.	Meter should indicate value of the resistors.	If no indication check power supply. Check bridge. Check voltage divider network. If readings are low, check voltage divider. Check switches S1 and S2 for dirty contacts (refer to table 5-2).
5	Set function switch to MILS position. Set range switch to range of current to be measured. Connect OHMS-MILS probe and COM in series with circuit.	Meter should read correct current.	If no indication on meter, check MILS divider circuit (refer to table 5-2).

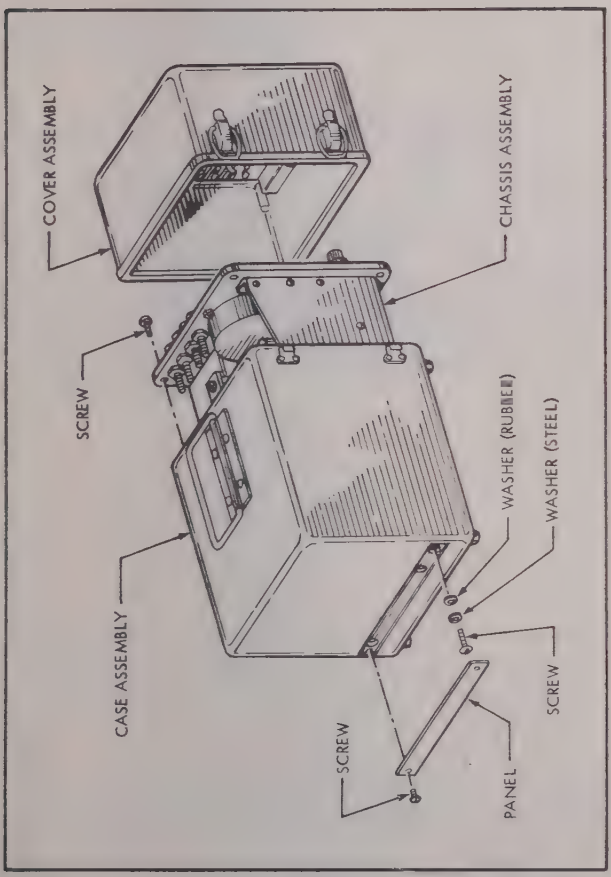

Figure 5-1. Electronic Multimeter AN USM-116, Partly Exploded View

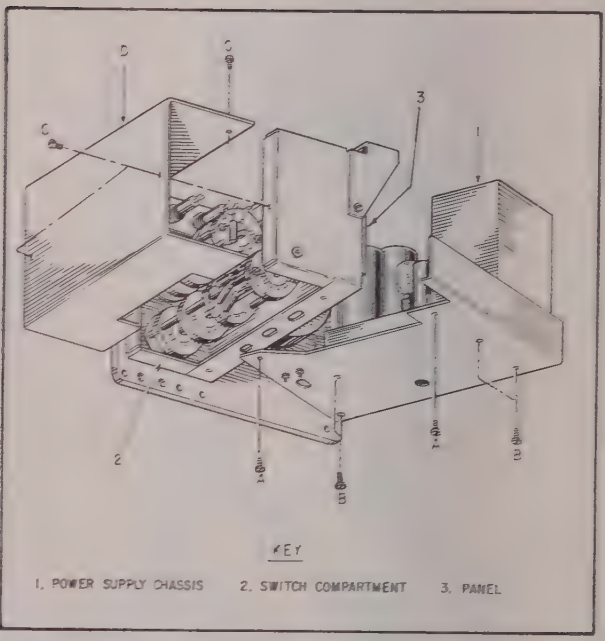

Figure 5-2. Electronic Multimeter AN/USM-116, Interior View

power supply chassis (1) away from the panels mounted on the stationary switch compartment (2).

(2) To gain access to components on underside of power supply chassis (1), remove screws (B) and lift up power supply chassis.

(3) To gain access to components within the

switch compartment (2) remove screws (C) and take off panel (D).

(4) All components within multimeter are now accessible for repair or replacement purposes.

c. FUNCTIONAL SECTION TROUBLE-SHOOTING CHART. - The functional trouble-shooting chart (refer to table 5-2) describes the checks that should be made to isolate the particular part at fault. Follow the instructions given in the table. Note that the second column of the table lists the test point symbols shown in figure 5-9. Refer to figure 5-3 for tube pin voltage and resistance measurements and for the tube location diagram.

5-5. TYPICAL TROUBLES.

Table 5-3 lists typical troubles which may develop within the multimeter. These are listed together with the nature of the trouble and its symptoms. Troubles should be remedied as described in tables 5-1 and 5-2.

5-6. FAILURE REPORT

Report each failure of the equipment, whether caused by a defective part, wear, improper operation or an external cause. Use ELECTRONIC FAILURE REPORT form DD787. Each pad of the forms includes full instructions for filling out the forms and forwarding them to the Bureau of Ships. However, the importance of providing complete information cannot be emphasized too much. Be sure that you include the model designation and serial number of the equipment (from the equipment identification plate), the type number and serial number of the major unit identification plate), and the type number

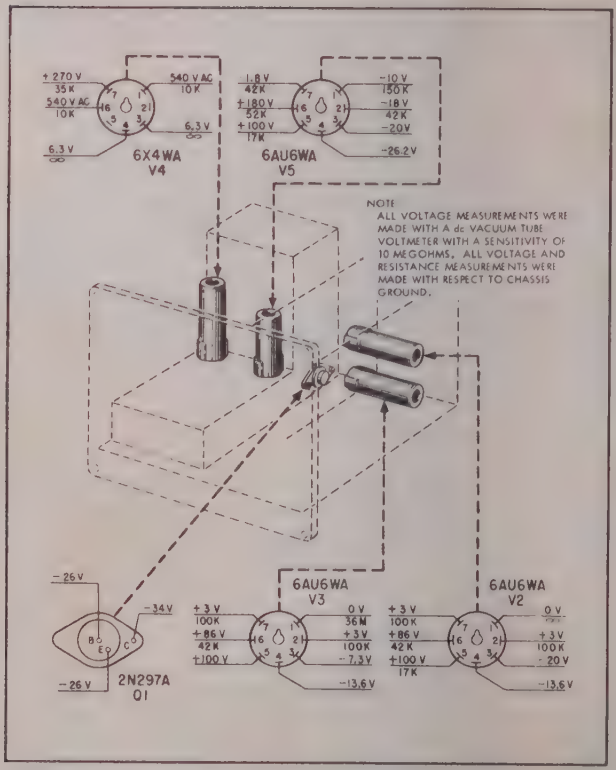

Figure 5-3. Voltage and Resistance Measurements and Tube Location Diagram

TABLE 5-2. FUNCTIONAL SECTION TROUBLE-SHOOTING CHART

Step	Test Point (Figure 5-9)	Preliminary Action	Normal Indication	Next Step
1	①	Place voltmeter between terminal 9 and 10 of T1. Place selector switch S1 to -DC position.	Voltage reading should be the same as line voltage.	If no voltage, check F3, F4 and primary of T1.
2	②	Place voltmeter between pin 7 of V4 and ground.	Voltage reading of 270V ±20%.	If voltage is low, replace V4, 6X4WA.
3	③	Place voltmeter between junction of R53 and ground.	Voltage reading of -55V ±10%.	If reading is abnormal check Q1, CR3, CR4, CR5 and C7.
4	④	Place voltmeter between pin 5 of V3 and ground.	Voltage reading of 100V ±20%.	If reading is incorrect, reset R50.

TABLE 5-2 FUNCTIONAL SECTION TROUBLESHOOTING CHART Cont

Step	Test Point (Figure 5-4)	Preliminary Action	Normal Indication	Next Step
5	(A)	Place voltmeter between junction of R43 and R42 and ground.	Voltage reading of 111V ± 10%.	If reading is incorrect, change V5, reset R50, check R43, replace VR2.
6	(B)	Place voltmeter between junction of pin 6 of V5 and R49 and ground.	Voltage reading of 160V ±10%.	If incorrect reading, replace V5, check R48 and R49.
7	(C)	Place voltmeter between junction of R49 and -55V.	Voltage reading of 80V ±20%.	If incorrect reading exists or reading fluctuates, replace VR3, check R52.

8	(E)	Disconnect CR1 and CR2 from circuit. Place ohmmeter across each diode.	Check forward and reverse resistance ratios.	If resistance ratios are not within tolerance, replace diodes.
9	(D)	Place voltmeter from pin 6 of V4 to terminal 2 of T1, then from pin 1 of V4 to terminal 2.	Voltmeter readings should be 225 volts ac for each plate.	If only one plate reads proper voltage check connection to socket. If connection is not at fault, replace transformer.
10	(5)	Place voltmeter between junction of CR5 and R54 and ground.	Voltage reading must be -26 V ±5%.	Make same checks as in step 3.
11	(E)	Place voltmeter across pins 7 and 8 of T1.	Voltage reading must be 6.3 volts ±10%.	If no voltage reading is evident, winding of transformer is open.

TABLE 5-3. AN/USM-116 MULTIMETER, TYPICAL TROUBLES

Trouble	Nature of Trouble	Symptoms
Ohmmeter readings incorrect	Resistance of fuse F1, too high; Contacts on switches in ohms circuit dirty.	Ohmic readings on lower ranges are noticeably erratic.
Meter readings on MILS scale inaccurate	Excessive leakage of diodes CR1 and CR2.	MILS ranges not accurate. More incorrect readings on high ranges.
Pointer on meter does not rest on zero.	Tubes V2 and V3 in bridge circuit gaseous.	When switching range switch through ranges, zero adjustment fluctuates.
DC voltage readings inaccurate	DC calibration control R26 needs adjustment.	Readings on all dc scales low.
AC voltage readings inaccurate	R28 set improperly.	AC voltage readings inaccurate on 1v range only.

	R29 set improperly.	AC voltage readings inaccurate on 3 v range only.
	R30 set improperly.	AC voltage readings inaccurate on 10 v range only.
	R31 set improperly.	AC voltage readings inaccurate on 30 v range only.
	R32 set improperly.	AC voltage readings inaccurate on 100 v range only.
	R33 set improperly.	AC voltage readings inaccurate on 300 v range only.
Meter readings fluctuate	Line voltage fluctuating - R50 needs to be adjusted. VR3 defective.	Meter fluctuates on all positions of switch except MILS.

and reference designation of the particular defective part (from the technical manual). Describe the cause of the failure completely, continuing on the back of the form if necessary. Do not substitute brevity for clarity. And remember--there are two sides to the failure report-

"YOUR SIDE"

"Every FAILURE REPORT is a boost for you:

1. It shows that you are doing your job.
2. It helps make your job easier.
3. It insures available replacements.
4. It gives you a chance to pass your knowledge to every man on the team.

"BUREAU SIDE"

"The Bureau of Ships uses the information to:

1. Evaluate present equipment.
2. Improve future equipment.
3. Order replacements for stock.
4. Prepare field changes.
5. Publish maintenance data.

Always keep a supply of failure report forms on board. You can get them from the nearest Forms and Publications Supply Point.

5-7. REMOVAL, ADJUSTMENT, REPAIR AND REASSEMBLY OF PARTS AND SUBASSEMBLIES.

a. REMOVAL. - To gain access to the interior of the multimeter for repair or replacement purposes, disassemble it as described in paragraph 5-4.

Note

The manufacturer recommends that removal of parts be performed by duly qualified electronics technicians only.

b. ADJUSTMENTS. - The adjustments required to compensate for aging of tubes and other components and for the changes caused by changes in circuit elements are described in table 5-2. No other adjustments are required.

c. REPAIR. - Minor repairs, such as removing scratches and burrs, replacing terminal lugs, soldering loose connections, etc., should be made in accordance with approved general shop practices. All details of workmanship should be in accordance with the best practice of high quality electrical equipment. Pay particular attention to neatness and thoroughness of soldering, wiring, clearance between soldered connections and removal of burrs and sharp edges.

(1) TUBE FAILURE. The majority of troubles within the multimeter will be caused by tube failure. Replacing the bad tube with a good one will frequently correct the trouble. It should be kept in mind, however, that tube failure may be caused by failure of a component in the same or in a related circuit. Be sure to check before installing new tubes. Often faulty components that cause tube failure can be found by visual inspection (discolored or burned

resistor, leaking or burned capacitors).

(a) Tube testers cannot be depended upon to find all possible defects in a tube. A more reliable method is to substitute tubes known to be serviceable for suspected faulty ones. This may save considerable time in trouble localizing since a tube which tests satisfactorily in a tube tester may fail in a particular application.

(2) CORROSION. Corrosion at a switch point should be removed carefully with an approved solvent.

(3) LEADS. To avoid capacitive and inductive coupling, be careful of lead dress when replacing defective components. All component leads must be mechanically fastened and soldered to terminals. After soldering, components must not be taut. Allow approximately 1 8-inch movement from centerline to prevent vibration damage.

(a) Replacement wiring must be the same size, type and length as original wiring. Run replacement wiring as close as possible to original routing.

(b) Approximately 1/4-inch of insulation should be stripped from ends of each lead wire. Strip just prior to soldering to prevent oxidation of bare wires.

(4) SOLDER. Solder all electrical connections per MIL-S-6872, using rosin core wire solder, Federal Specification QQ-S-571, Type Sn60. Check to see that solder at joint is bright and shiny and that a good mechanical as well as electrical connection has been made.

(5) TRANSISTOR. When installing transistor Q1 be sure to reinstall the non-metallic insulators between the transistor and chassis.

(6) POLARIZED COMPONENTS. Exercise care to observe the correct polarity when replacing silicon diodes, electrolytic capacitors and the transistor Q1.

CAUTION

Always double-check installation of polarized components for proper connections as shown in figure 5-9 before applying power to the multimeter.

(7) DISASSEMBLY OF AC PROBE. To replace electron tube V1 in the ac probe (see figure 5-8), proceed as follows:

(a) Loosen the bushing at the cable-end of the probe and slide it back about eight to ten inches along the cable.

(b) Unscrew the rear housing from the front housing and slide it away from the probe tip until the sleeve is exposed.

Note

The insulating tubing may pull out of the rear housing as the rear housing is moved. If it does, simply press it back into place.

(c) Unsolder the tube heater leads and the lead to resistor R1 at the eyelets on the sleeve.

(d) Remove the outer ring which secures the teflon cup to the front housing. Take off the teflon cup and prod point assembly.

(e) Carefully remove the spring clip from the anode tip of tube V1. Unscrew and remove the inner ring. Electron tube V1 can now be withdrawn from the probe.

(8) REASSEMBLY OF AC PROBE. Reassembly of the ac probe is essentially a reversal of the steps described in paragraph (7). The following precautions, however, should be observed.

(a) Always provide tube V1 with protection against breakage. Be sure to put the teflon cup over the anode lead before resoldering heater leads at the eyelets on the sleeve.

(b) When replacing the spring clip exercise special care not to break the anode lead on V1.

(c) When re-positioning the sleeve, gently press it against the rear end of tube V1. Bring one tube heater lead through each slot in the sleeve. Then solder the lead to the eyelet.

CAUTION

Be especially careful to re-install the insulating tubing properly (on the inside bore of the rear housing). If the insulating tubing is not replaced, components can be damaged by a short circuit to ground. This might also cause an electrical shock to personnel.

(9). REPLACEMENT OF COILS AND CAPACITOR IN AC PROBE. To gain access to coils L1, L2 and L3 and capacitor C1, for replacement purposes, disassembly the probe as described in paragraph (7). steps (a) through (e).

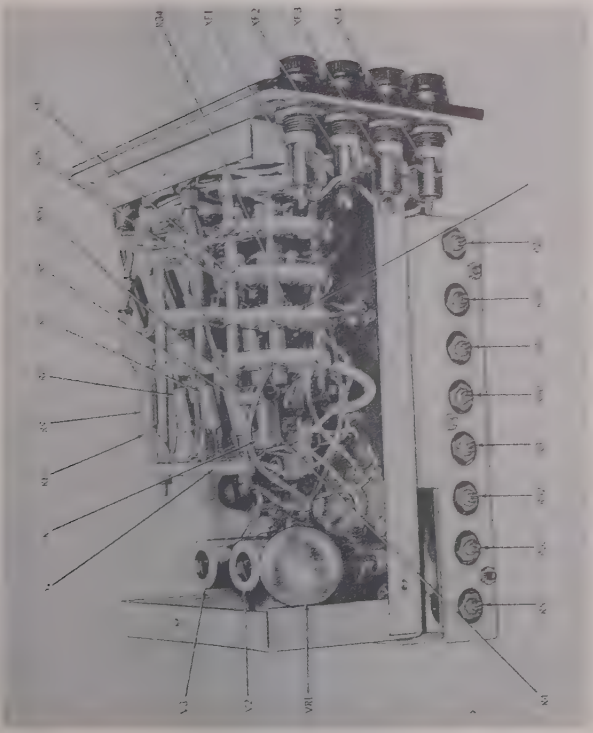

Figure 5-4. Main Chassis Assembly with Switch Cover Removed

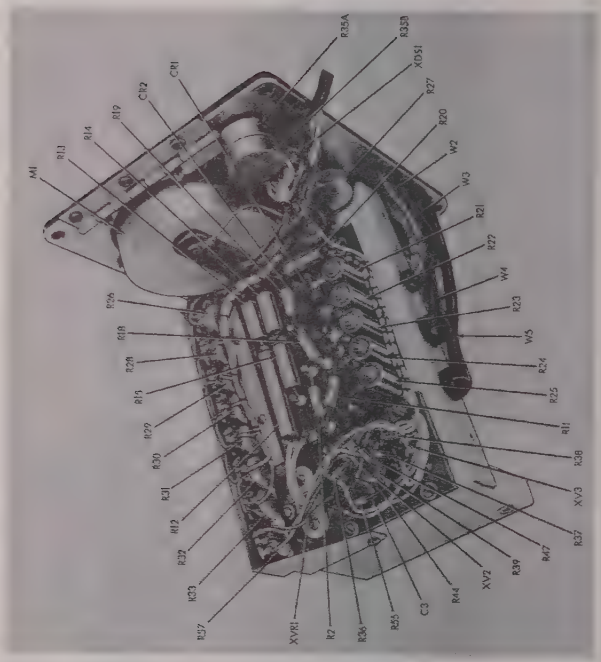

Figure 5-5. Main Chassis Assembly Showing Terminal Board

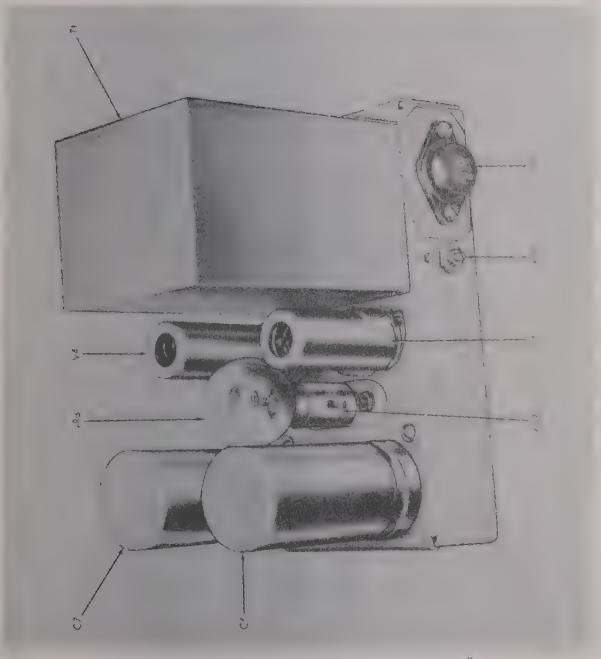

Figure 5-6. Top View of Power Supply Chassis

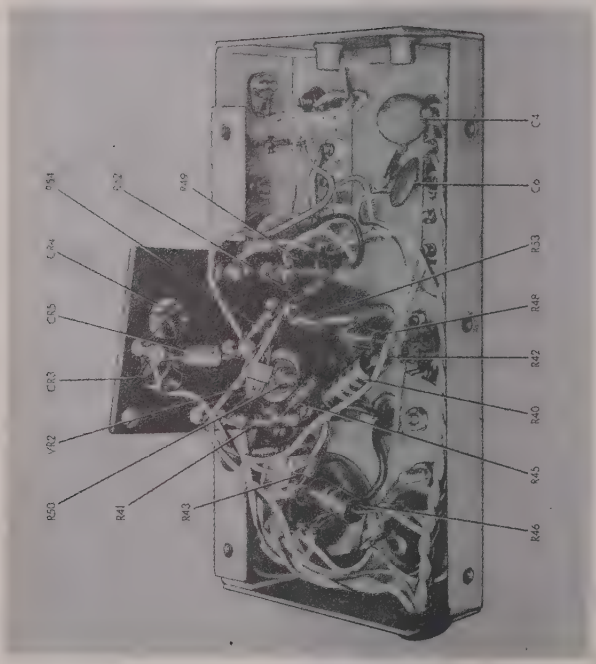

Figure 5-7. Bottom View of Power Supply Chassis with Terminal Board Tilted Upward to Show Components on Underside

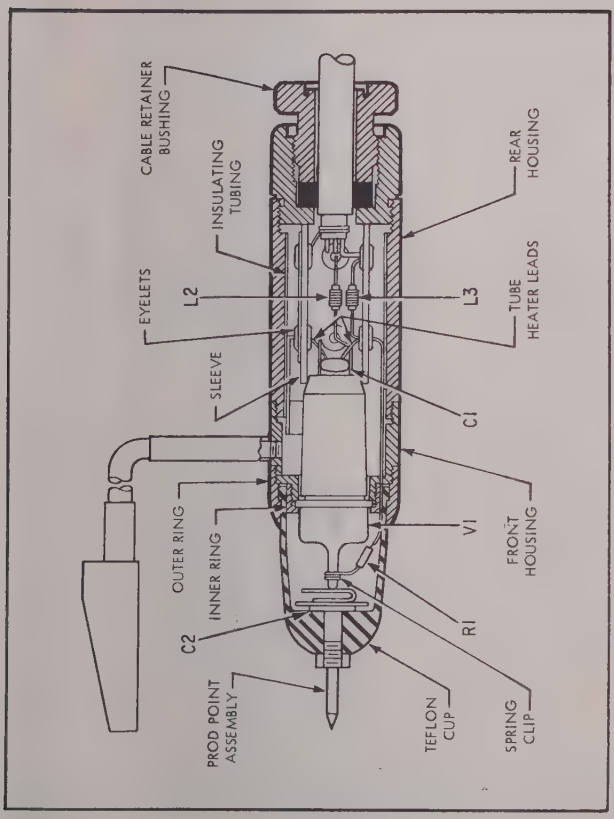

Figure 5-8. AC Probe, Location of Components

NOTES

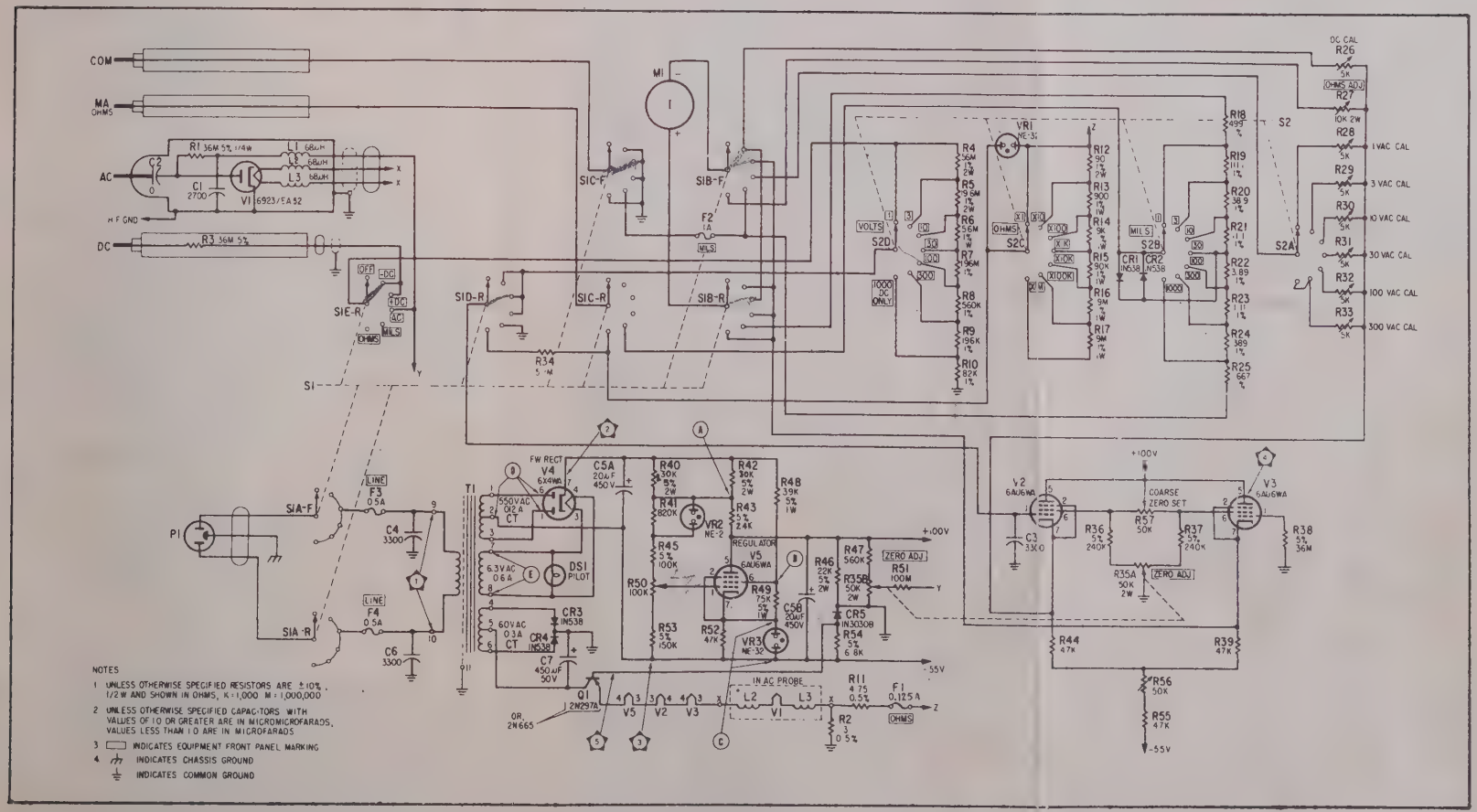

Figure 5-9. Electronic Multimeter AN/USM-116, Overall Schematic

SECTION 6
PARTS LIST

6-1. INTRODUCTION.

Reference designations have been assigned to identify all maintenance parts of the equipment. They are used for marking the equipment (adjacent to the part they identify when practical) and are included on drawings, diagrams and the parts list. *The letters* of the reference designation indicate the kind of part (generic group), such as resistor, capacitor, electron tube, etc. *The number* differentiates between parts of the same group. Parts are numbered from 1 to 99. Sockets associated with a particular plug-in device such as an electron tube, fuse or lamp are identified by a reference designation which includes the reference designation of the plug-in device. For example, the socket for electron tube V1 is designated XV1 and the fuseholder for fuse F1 is XF1.

6-2. MAINTENANCE PARTS LIST.

Table 6-1 lists all maintenance parts for the equipment. Column 1 lists the reference designations in alphanumeric sequence. Column 2 refers to explanatory notes that may appear in paragraph 6-5. Column 3 gives the name and brief description of all key parts (parts differing from any part previously listed in the table). The name and description are omitted for other parts and the notation "Same as (followed by the reference designation of

the corresponding key part)" is substituted. Column 4 indicates how the part is used and gives its functional location in the equipment. It also includes the pictorial illustration, if any, on which the part is identified.

6-3. STOCK NUMBER IDENTIFICATION.

Stock numbers of parts used in this equipment can be obtained by referring to the Stock Number Identification Table (SNIT) published by E.S.O.

6-4. LIST OF MANUFACTURERS.

Table 6-2 lists manufacturers of parts used in the equipment. The first column indicates the abbreviations used in table 6-1 to identify manufacturers.

6-5. NOTES.

The following provides additional information about items listed in table 6-1.

a. For replacement use type 2N665.

TABLE 6-1. MAINTENANCE PARTS LIST

Ref Desig	Notes	Name and Description	Locating Function
C1		CAPACITOR, FIXED, CERAMIC DIELECTRIC: 2700 uuf, -0 - tolerance not rated, 500 v dc, insulated body, 0.280 in. dia by 5 32 in. thk, Erie type no. 831Z5V	Bypass capacitor in rectified AC circuit from diode V1 in AC probe. Figure 5-8.
C2		CAPACITOR, FIXED, CERAMIC DIELECTRIC: single section, 10000 uuf, -0 - tolerance not rated, 500 v dc, uninsulated body, 0.531 in. dia approx by 0.022 in. thk approx, AB type no. B36-103W, Hickok part/dwg no. 3110-84	AC input coupling capacitor to V1 in AC probe. Figure 5-8.
C3		CAPACITOR, FIXED, CERAMIC DIELECTRIC: single section, 3300 uuf, ± 20%, 500 v dc, MIL-C-11015B type no. CK62AW332M	Bypass capacitor on grid pin 1 of V2. Figure 5-5.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
C4		Same as C3	Bypass capacitor on input of AC line. Figure 5-7.
C5		CAPACITOR, FIXED, ELECTROLYTIC: 2 sections, 20 uf - 450 v ea section, MIL-C-62A type no. CE42F200R	Figure 5-6.
C5A		Part of C5	Filter capacitor in DC voltage supply circuit from cathode of V4 to B-. Figure 5-6.
C5B		Part of C5	Filter capacitor in DC voltage supply from plates of V2, V3 and V5 to B-. Figure 5-6.

C6		Same as C3	Bypass capacitor on input of AC line. Figure 5-7.
C7		CAPACITOR, FIXED, ELECTROLYTIC: 1 section, 450 uf, 50 v, MIL-C-62A type CE41C451G	Filter capacitor in DC heater voltage supply circuit from anodes of CR3 and CR4 to Q1 collector. Figure 5-6.
CR1		SEMICONDUCTOR DEVICE, DIODE: MIL-E-1D type no. 1N538	Protective diode for MILLI-AMPERE shunts. Figure 5-5.
CR2		Same as CR1	Protective diode for MILLI-AMPERE shunts. Figure 5-5.
CR3		Same as CR1	Rectifier diode for DC heater voltage supply. Figure 5-7.
CR4		Same as CR1	Rectifier diode for DC heater voltage supply. Figure 5-7.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
CR5		SEMICONDUCTOR DEVICE, DIODE Motorola part no. 1N3030B	Voltage reference diode in DC heater supply circuit. Figure 5-7.
DS1		LAMP, INCANDESCENT 6.3 v, 0.2 amp. GE part no. 328	On-off pilot lamp. Figure 5-5.
E1		ADAPTER, RADIO FREQUENCY CABLE UG-1447/USM-116 (COAXIAL TEE CONNECTOR) adapts rf cable to ac probe. Hickok part no. 3475-103	Used with AC probe when measuring rf voltages on coaxial transmission lines.
E2		NETWORK, IMPEDANCE MATCHING CU-1044/USM-116 (COAXIAL TERMINATION PLUG) Hickok part no. 18599-2	Matched load used with RF cable adapter (E1) when making measurements on unterminated transmission lines.

E3		CLIP, ELECTRICAL: copper, nickel-plated finish, w/insulating sleeve, Hickok part no. 3300-103	Used with "COMMON" test lead W3.
F1		FUSE, CARTRIDGE: 1/8 amp, 125 v, high speed instantaneous acting, Littelfuse part no. 360036 modified, Hickok part no. 6900-31	OHMS circuit protection fuse. Figure 5-4.
F2		FUSE, CARTRIDGE: 1 amp, 250 v, normal instantaneous acting, Littelfuse part no. 312001	MILLIAMPERE circuit protection fuse. Figure 5-4.
F3		FUSE, CARTRIDGE: 1/2 amp, 125 v, time delay type, Littelfuse part no. 313.500	Protective fuse in primary circuit of T1. Figure 5-4.
F4		Same as F3	Protective fuse in primary circuit of T1. Figure 5-4.
L1		COIL, RADIO FREQUENCY: 0.68 uh nom inductance, 0.1 ohm dc resistance, Wilco part no. 203-11	Choke for isolating any AC voltages appearing on AC probe.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
L2		Same as L1	Choke for isolating any AC voltages appearing on AC probe. Figure 5-8.
L3		Same as L1	Choke for isolating any AC voltages appearing on AC probe. Figure 5-8.
M1		MULTIMETER, REPLACEMENT: 7 scales, calibrated in ac volts - dc volts - dc mils and ohms, for use only on Multimeter AN USM-116, Hickok part no. 481-826	Indicating instrument for all measurements and ranges. Figure 5-5.
P1		CONNECTOR, PLUG, ELECTRICAL: 2 blade type contacts, w grounding contact screw mtd on shell. MIL-C-3767A type no. UP121M	Power cable connector plug, p/o W1.

Q1	a	TRANSISTOR: MIL-T-19500 type no. 2N297A	Series voltage regulator in DC heater voltage supply circuit. Figure 5-6.
R1		RESISTOR, FIXED, COMPOSITION: 36 megohms, ±5%, 1/4 w, AB part no. CB3665	Decoupling resistor in AC probe. Figure 5-8.
R2		RESISTOR, FIXED, FILM: 3 ohms, ±1%, 1/2 w, Electra type no. DCM1/2	Part of ohmmeter DC supply circuit. Figure 5-5.
R3		RESISTOR, FIXED, COMPOSITION: 36 megohms, ±5%, 1/2 w, AB part no. EB3665	Series resistor in DC probe.
R4		RESISTOR, FIXED FILM: 56 megohms, ±1%, 2 w, Electra type no. DCM2	Part of voltage dividing network. Figure 5-4.
R5		RESISTOR, FIXED, FILM: 19.6 megohms, ±1%, 2 w, Electra type no. DCM2	Part of voltage dividing network. Figure 5-4.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
R6		RESISTOR, FIXED, FILM: 5.6 megohms, ±1%, 1 w, Electra type no. DCM1	Part of voltage dividing network. Figure 5-4.
R7		RESISTOR, FIXED, FILM: 1.96 megohms, ±1%, 1/2 w, Electra type DCM1/2	Part of voltage dividing network. Figure 5-4.
R8		RESISTOR, FIXED, FILM: 560, 000 ohms, ±1%, 1/2 w, Electra type no. DCM1/2	Part of voltage dividing network. Figure 5-4.
R9		RESISTOR, FIXED, FILM: 196, 000 ohms, ±1%, 1/2 w, Electra type no. DCM1/2	Part of voltage dividing network. Figure 5-4.
R10		RESISTOR, FIXED, FILM: 82,000 ohms, ±1%, 1/2 w, Electra type no. DCM1/2	Part of voltage dividing network. Figure 5-4.

R11	RESISTOR, FIXED, FILM: 4.75 ohms, ±1%, 1/2 w, MIL-R-10509C type no. RN70B4R75F, Electra type no. DCM1/2	Part of OHMS dividing network. Figure 5-5.
R12	RESISTOR, FIXED, FILM: 90 ohms, ±1%, 2 w, Electra type no. DCM2	Part of OHMS dividing network. Figure 5-5.
R13	RESISTOR, FIXED, FILM: 900 ohms, ±1%, 1 w, Electra type no. DCM1	Part of OHMS dividing network. Figure 5-5.
R14	RESISTOR, FIXED, FILM: 9000 ohms, ±1%, 1 w, Electra type no. DCM1	Part of OHMS dividing network. Figure 5-5.
R15	RESISTOR, FIXED, FILM: 90000 ohms, ±1%, 1 w, Electra type no. DCM1	Part of OHMS dividing network. Figure 5-5.
R16	RESISTOR, FIXED, FILM: 900,000 ohms, ±1%, 1 w, Electra type DCM1	Part of OHMS dividing network. Figure 5-4.
R17	RESISTOR, FIXED, FILM: 9 megohms, ±1%, 1 w, Electra type no. DCM1	Part of OHMS dividing network. Figure 5-4.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
R18		RESISTOR, FIXED, WIRE WOUND: 499 ohms, ±1%, 1/4 w, MIL-R-93C type no. RB54AE499R0F	Part of MILLIAMPERE dividing network. Figure 5-5.
R19		RESISTOR, FIXED, WIRE WOUND: 111.1 ohms, ±1%, 1/4 w, MIL-R-93C type no. RB54AE111R1F	Part of MILLIAMPERE dividing network. Figure 5-5.
R20		RESISTOR, FIXED, WIRE WOUND: 38.9 ohms, ±1%, 1/4 w, MIL-R-93C, type no. RB54AE38R90F	Part of MILLIAMPERE dividing network. Figure 5-5.
R21		RESISTOR, FIXED, WIRE WOUND: 11.1 ohms, ±1%, 1/2 w, MIL-R-93C type no. RB17AE11R10F	Part of MILLIAMPERE dividing network. Figure 5-5.

R22		RESISTOR, FIXED, WIRE WOUND: 3.89 ohms, ±1%, 1/2 w, MIL-R-93C type no. RB17AE3R890F	Part of MILLIAMPERE dividing network. Figure 5-5.
R23		RESISTOR, FIXED, WIRE WOUND: 1.11 ohms, ±1%, 1/2 w, MIL-R-93C type no. RB17AE1R110F	Part of MILLIAMPERE dividing network. Figure 5-5.
R24		RESISTOR, FIXED, WIRE WOUND: 0.389 ohms, ±1%, 1/2 w, MIL-R-93C type no. RB17AER 389F	Part of MILLIAMPERE dividing network. Figure 5-5.
R25		RESISTOR, FIXED, WIRE WOUND: 0.1667 ohms, ±1%, 1/2 w, MIL-R-93C type no. RB17AER1667F	Part of MILLIAMPERE dividing network. Figure 5-5.
R26		RESISTOR, VARIABLE: composition element, 5000 ohms, ±10%, 1/2 w, std A taper, slotted single 1/4 in. dia metal shaft 3/8 in. lg from mtg surface, normal torque, MIL-R-94B type no. RV5NAXSL502A	DC VOLTS calibration control. Figure 5-4 and Figure 5-5.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
R27		RESISTOR, VARIABLE: composition element, 10000 ohms, ±10%, 2 w, std A taper, plain 1/4 in. dia shaft 7/8 in. lg from mtg surface, normal torque, CTS part no. HY20978CTS6001	OHMS adjustment control. Figure 5-5.
R28		Same as R26	AC VOLTAGE calibration control. Figure 5-4 and Figure 5-5.
R29		Same as R26	AC VOLTAGE calibration control. Figure 5-4 and Figure 5-5.
R30		Same as R26	AC VOLTAGE calibration control. Figure 5-4 and Figure 5-5.

R31	Same as R26	AC VOLTAGE calibration control. Figure 5-4 and Figure 5-5.
R32	Same as R26	AC VOLTAGE calibration control. Figure 5-4 and Figure 5-5.
R33	Same as R26	AC VOLTAGE calibration control. Figure 5-4 and Figure 5-5.
R34	RESISTOR, FIXED, COMPOSITION: 5 megohms, ±10%, 1/2 w, MIL-R-11C type no. RC20GF505K, AB part no. EB5051	Part of OHMS protection circuit. Figure 5-4.
R35	RESISTOR, VARIABLE: composition element, 2 sections, 50000 ohms - ±10% - 2 w ea section, std A taper, dual concentric shafts; outer shaft 1/4 in. dia by 1 in. lg, inner shaft 1/8 in. dia by 1-3/8 in. lg from mtg surface, normal torque, CTS part no. HY2097750KCTS6001	Figure 5-5.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
R35A		Part of R35	DC ZERO control. Figure 5-5.
R35B		Part of R35	AC ZERO control, part of contact potential bucking network. Figure 5-5.
R36		RESISTOR, FIXED, COMPOSITION: 240,000 ohms, ±5%, 1 2 w, MIL-R-11C type no. RC20GF244J, AB part no. EB2445	Part of screen voltage supply network of V2. Figure 5-5.
R37		Same as R36	Part of screen voltage supply network of V3. Figure 5-5.
R38		Same as R3	Control grid resistor of V3. Figure 5-5.

R39	RESISTOR, FIXED, COMPOSITION: 47,000 ohms, ±10%, 1/2 w, MIL-R-11C type no. RC20GF473K, AB part no. EB4731	Cathode resistor of V3. Figure 5-5.
R40	RESISTOR, FIXED, COMPOSITION: 30,000 ohms, ±5%, 2 w, MIL-R-11C type no. RC42GF303J, AB part no. HB3035	Series resistor, part of B+ voltage circuit. Figure 5-7.
R41	RESISTOR, FIXED, COMPOSITION: 820,000 ohms, ±10%, 1/2 w, MIL-R-11C type no. RC20GF824K, AB part no. EB8241	Part of voltage regulator reference dividing network. Figure 5-7.
R42	Same as R40	Series resistor, part of B+ voltage circuit. Figure 5-7.
R43	RESISTOR, FIXED, COMPOSITION: 2400 ohms, ±5%, 1/2 w, MIL-R-11C type no. RC20GF242J, AB part no. EB2425	Series resistor, part of B+ voltage circuit. Figure 5-7.
R44	Same as R39	Cathode resistor of V2. Figure 5-5.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
R45		RESISTOR, FIXED, COMPOSITION: 100,000 ohms, ±5%, 1 2 w, MIL-R-11C type no. RC20GF104J, AB part no. EB1045	Part of voltage regulator reference dividing network. Figure 5-7.
R46		RESISTOR, FIXED, COMPOSITION: 22,000 ohms, ±5%, 2 w, MIL-R-11C type no. RC42GF223J, AB part no. HB2235	B+ supply voltage load resistor. Figure 5-7.
R47		RESISTOR, FIXED, COMPOSITION: 560,000 ohms, ±10%, 1 2 w, MIL-R-11C type no. RC20GF564K, AB part no. EB5641	Part of AC contact potential bucking network. Figure 5-5.
R48		RESISTOR, FIXED, COMPOSITION: 39,000 ohms, ±5%, 1 w, MIL-R-11C type no. RC32GF393J, AB part no. GB3935	Part of screen voltage divider of V5. Figure 5-7.

R49		RESISTOR, FIXED, COMPOSITION: 75,000 ohms, ±5%, 1 w, MIL-R-11C type no. RC32GF753J, AB part no. GB7535	Part of screen voltage divider of V5. Figure 5-7.
R50		RESISTOR, VARIABLE: composition element, 100,000 ohms, ±10%, 1/2 w, std A taper, slotted single 1/4 in. dia shaft 3/8 in. lg from mtg surface, normal torque, MIL-R-94B type no. RV5NAXSL104A	B+ voltage calibration control. Figure 5-7.
R51		RESISTOR, FIXED, COMPOSITION: 100 megohms, ±10%, 2 w, AB part no. HB1071	Part of AC volts contact potential bucking network. Figure 5-4.
R52		Same as R39	Cathode resistor for V5. Figure 5-7.
R53		RESISTOR, FIXED, COMPOSITION: 150,000 ohms, ±5%, 1/2 w, MIL-R-11C type no. RC20GF154J, AB part no. EB1545	Part of voltage reference divider network. Figure 5-7.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
R54		RESISTOR, FIXED, COMPOSITION: 6800 ohms, ±5%, 1/2 w, MIL-R-11C type no. RC20GF682J, AB part no. EB6825	Part of DC heater voltage supply reference network. Figure 5-7.
R55		Same as R39	Bias resistor for V2 and V3. Figure 5-5.
R56		RESISTOR, VARIABLE: composition element, 50,000 ohms, ±10%, 1/2 w, std A taper, slotted single, 1/4 in. dia shaft 3/8 in. lg from mtg surface, normal torque, MIL-R-94B type no. RV5NAXSL503A	Bias adjust control for V2 and V3. Figure 5-6.
R57		Same as R56	Course DC zero control. Figure 5-3 and Figure 5-5.

S1		SWITCH, ROTARY: 5 sections, 6 positions, ceramic insulation, shorting type contacts, Hickok part no. 19912-423	FUNCTION selector switch. Figure 5-4.
S2		SWITCH, ROTARY: 5 sections, 7 positions, ceramic insulation, shorting type contacts, Hickok part no. 19912-424	RANGE selector switch. Figure 5-4.
T1		TRANSFORMER, POWER, STEP-DOWN AND STEP-UP: 115 v - 50 to 400 cps primary, three secondary windings; 550 v at 0.024 amp center tapped, 60 v at 0.6 amp center tapped and 6.3 v at 0.6 amp, Hickok part no. 20800-240	Supplies AC voltages for plate and filament supply. Figure 5-6.
V1		ELECTRON TUBE: U.H.F. diode, Amperex type no. 6923/EA52	AC voltage detector used in AC probe W5.
V2		ELECTRON TUBE: sharp cut-off amplifier pentode, MIL-E-1D type no. 6136/6AU6WA	Used in one-half of bridge circuit. Figure 5-4.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
V3		Same as V2	Used in one-half of bridge circuit. Figure 5-4.
V4		ELECTRON TUBE: full wave rectifier, MIL-E-1D type no. 6X4WA	Rectifier, plate voltage supply. Figure 5-6.
V5		Same as V2	Used in series regulator circuit. Figure 5-6.
VR1		LAMP, GLOW: neon, 1 w, 60 v ac - 85 v dc striking voltage, GE type no. NE-32	Part of OHMS protection circuit. Figure 5-4.
VR2		LAMP, GLOW: neon, 1/25 w, 65 v ac - 90 v dc striking voltage, GE type no. NE-2	Part of B+ voltage reference circuit. Figure 5-7.
VR3		Same as VR1	B- voltage regulator. Figure 5-6.

W1		CABLE ASSEMBLY, POWER, ELECTRICAL: Hickok part no. 3030-137	Power input cable.
W2		LEAD, TEST: Hickok part no. 12450-347	OHMS-MILS test lead. Figure 5-5.
W3		LEAD, TEST: Hickok part no. 12450-348	COMMON test lead. Figure 5-5.
W4		LEAD, TEST: Hickok part no. 3030-136	DC probe test lead. Figure 5-5.
W5		PROD, TEST: MX-4049/USM-116 Hickok part no. 16970-50	AC probe test lead. Figure 5-5.
W6		LEAD, ELECTRICAL: Hickok part no. 12450-349	Ground lead used with AC probe.
XDS1		LIGHT, INDICATOR: red, Dial Light part no. 108-3830-131	On-off indicator light socket for no. 328 lamp DS1. Figure 5-5.

TABLE 6-1. MAINTENANCE PARTS LIST (Cont.)

Ref Desig	Notes	Name and Description	Locating Function
XF1		FUSEHOLDER: extractor post type, 125 v at 5 amp, Bussman part no. HJM-EJLRQW-ZZ	Holder for OHMS circuit protection fuse F1. Figure 5-4.
XF2		FUSEHOLDER: extractor post type, 250 v at 15 amp, MIL-Std-242C type no. FD-1, Bussman part no. HKP-EJLORW-ZZ	Holder for MILLIAMPERE circuit protection fuse F2. Figure 5-4.
XF3		Same as XF2	Holder for 0.5 amp transformer primary protection fuse F3. Figure 5-4.
XF4		Same as XF2	Holder for 0.5 amp transformer primary protection fuse F4. Figure 5-4.
XV1		Not assigned	

XV2	SOCKET, ELECTRON TUBE: 7 pin miniature type, w/ shield base, mica filled phenolic body, MIL-S-12883A type no. TS102P01	Socket for type 6136/ 6AU6WA sharp cut-off amplifier tube V2. Figure 5-5.
XV3	Same as XV2	Socket for type 6136/ 6AU6WA sharp cut-off amplifier tube V3. Figure 5-5.
XV4	Same as XV2	Socket for type 6X4WA rectifier tube V4.
XV5	Same as XV2	Socket for type 6136/ 6AU6WA sharp cut-off amplifier tube V5.
XVR1	LAMPHOLDER: 125 v, 75 w, Drake part no. A950L	Holder for NE-32 neon glow lamp VR1. Figure 5-5.
XVR2	Not assigned	
XVR3	Same as XVR1	Holder for NE-32 neon glow lamp VR3. Figure 5-6.

TABLE 6-2. LIST OF MANUFACTURERS

Abbreviation	Name	Address
AB	Allen-Bradley Co.	224 W. Greenfield Ave., Milwaukee 4, Wis.
Amperex	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	230 Duffy Ave., Hicksville, L.I., N.Y.
Bussman	Bussman Fuse Div. of McGraw-Edison Co.	University at Jefferson, St. Louis 7, Mo.
CTS	Chicago Telephone Supply Co.	1142 W. Beardsley Ave., Elkhart, Ind.
Dial Light	Dial Light Corp.	60 Stewart Ave., Brooklyn 37, N.Y.
Drake	Drake Mfg. Co.	1713 W. Hubbard St., Chicago 22, Ill.

Electra	Electra Mfg. Co.	4051 Broadway, Kansas City 11, Mo.
Erie	Erie Resistor Corp.	644 W. 12th St., Erie, Pa.
GE	General Electric Co., Lamp Div.	1133 East 152nd St., Cleveland 10, Ohio
Hickok	Hickok Electrical Instrument Co.	10514 Dupont Ave., Cleveland 8, Ohio
Littelfuse	Littelfuse, Inc.	1865 Miner St., Des Plaines, Ill.
Motorola	Motorola, Inc., Semiconductor Products Div.	5005 East McDowell Rd., Phoenix, Ariz.
Wilco	Wilco Corp.	546 Drover St., Indianapolis 21, Ind.

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